EXPLORE

NOAA OFFICE OF

OCEAN EXPLORATION

2003 Annual Report

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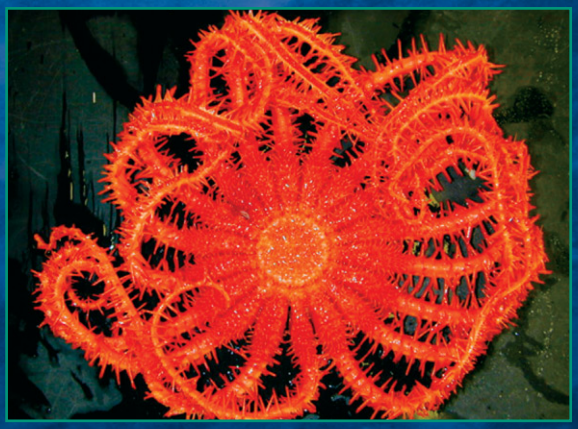

ACKNOWLEDGEMENTS

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MESSAGE FROM UNDER SECRETARY OF COMMERCE FOR OCEANS AND ATMOSPHERE & NOAA ADMINISTRATOR

In just three short years and with limited resources, the National Oceanic and Atmospheric Administration's (NOAA) Office of Ocean Exploration has achieved solid results in basic exploration and mapping the ocean floor, as well as in education and outreach efforts. These achievements were built on a strong foundation of partnerships. I am proud to present their 2003 report.

Expeditions in 2003 added to our knowledge of deep-sea volcanoes along the Earth's submarine Ring of Fire. They brought marine organisms from the seafloor of the Gulf of Mexico to laboratories for study as healing agents in a growing list of medicines from the sea. Teams of scientists learned more about precious deep-sea corals in the remote Northwestern Hawaiian Islands, and studied deep-water habitats on seamounts in the North Atlantic, at the Charleston Bump in the South Atlantic, and in the Gulf of Mexico. An expedition to Blake Plateau in the South Atlantic brought up organisms that thrived where no sunlight reaches, but where life is supported by methane gas seeping from ocean sediments.

In 2003, the ocean provided more information about our history and culture. With partners, NOAA explored ancient shipwrecks in the Black Sea and studied the condition of other sunken vessels of historic importance including USS *Arizona* in Pearl Harbor; RMS *Titanic* in the North Atlantic; and U-166, a German U-boat sunk in the Gulf of Mexico during WW II. Again with partners, NOAA searched for the remains of the *Gaspee* and other American Revolutionary War wrecks and researched possible locations of USS *Alligator*, a Civil War era submarine lost in a storm off Cape Hatteras.

Mapping is a fundamental component of ocean exploration. It is the first critical step for planning focused explorations and scientific investigations. With partners, NOAA's Office of Ocean Exploration surveyed more than 50,000 square nautical miles of new ocean area including the Mariana Arc and the Puerto Rico Trench, the deepest area of the Atlantic ocean. In the Arctic, NOAA and academic partners mapped more than 1,500 nautical miles where Alaska's continental slope is 2,500 meters deep. This information is critical for both expanding our understanding of the U.S. Exclusive Economic Zone (EEZ), and supporting possible future extensions of the EEZ where potential resources valued at $1.3 trillion are estimated to exist.

While 2003 was an exciting and productive year, there are challenges ahead. New sensors and systems will help meet those challenges, and NOAA will rely more than ever on strong partnerships. Our fundamental view of the ocean has changed. For thousands of years, people looked across the ocean and asked, "What lies beyond?" Today we ask, "What lies below?" Those deep mysteries will be answered by ocean exploration.

Conrad C. Lautenbacher, Jr.
Vice Admiral, U.S. Navy (Ret.)
Under Secretary of Commerce for Oceans and Atmosphere

MESSAGE FROM DIRECTOR OF NOAA'S OFFICE OF OCEAN EXPLORATION

The 2003 Field Season was an exciting year for NOAA's Office of Ocean Exploration. We funded, organized, and sailed with interdisciplinary teams of world-class scientists, where there was always the excitement of exploring and mapping new areas of the ocean. We wrote new chapters in history while excavating old shipwrecks, found new species of life, and investigated chemical compounds in ocean organisms that might cure cancer or other diseases.

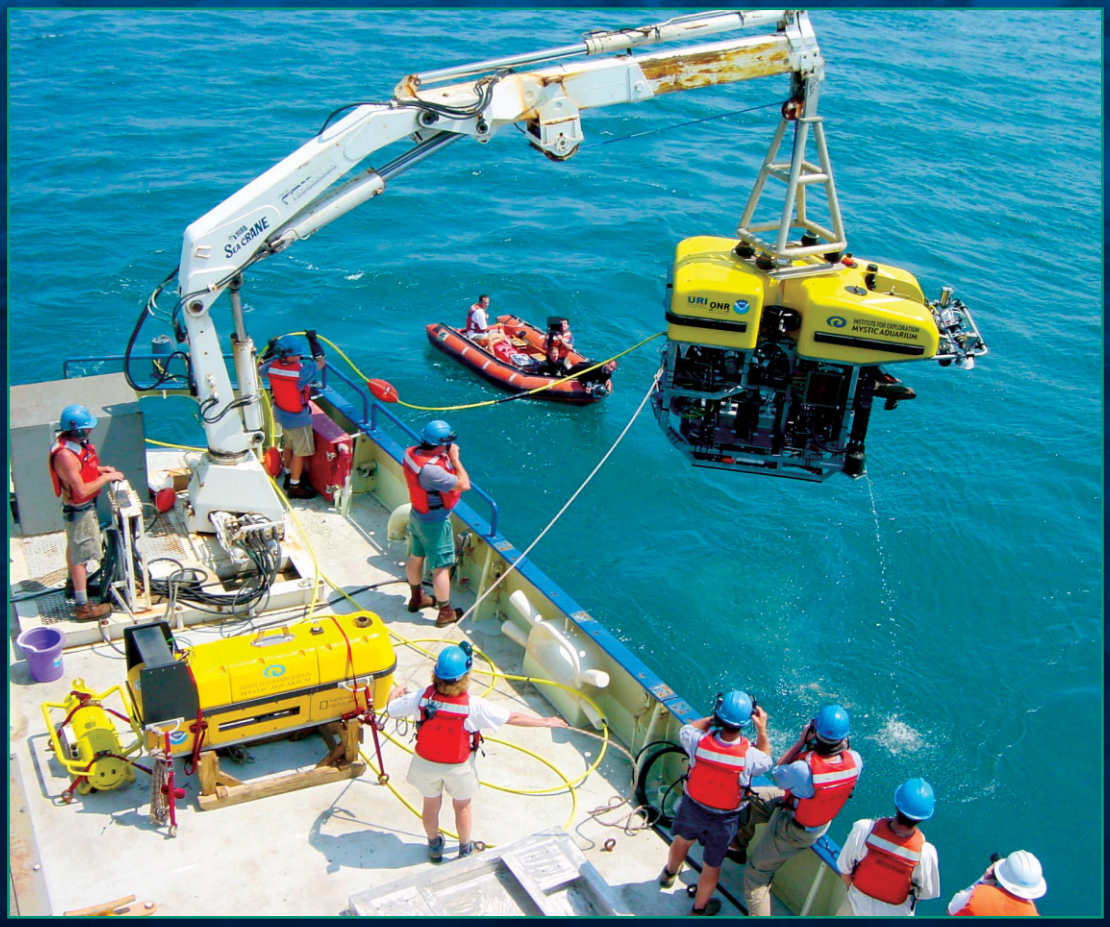
There was also the excitement of sharing these new discoveries with students, teachers, scientists, and indeed with all interested taxpayers. We reached out to those audiences in a number of ways. This annual report is one example, but there are many others. Thus far, 150 lesson plans, centered on our expeditions, have been written for grades 5-12. We also sponsored Professional Development Institutes nationwide for teachers to bring the joy of science and exploration into the classroom. Open houses were held at the end of many expeditions and students toured research vessels and interacted with scientists in the labs on those ships. It is hard to say who got the most out of those interactions—the scientists or the students. Some students may go on to be scientists or perhaps science teachers. All the students learned more about our oceans and their increased ocean literacy will be vital when as taxpayers and voters, they'll face decisions about the future of our oceans.

The shared excitement of our voyages of discovery is available to anyone who visits www.oceanexplorer.noaa.gov. where stories of discovery are told in mission summaries, accompanied by still and moving images from the deep oceans. Many expeditions read like daily newspapers, where scientists file daily mission logs at sea, and the reader is along for the ride. The smell of salty air and the rise and drop of the research vessel in heavy seas are not far from the readers' senses.

Again in 2003 we operated at a fast pace. First we called for proposals and had a distinguished group of scientists peer-review those proposals. We then selected expeditions and projects based on reviews and other considerations including the availability of funds, ships, manned submersibles and remotely operated vehicles. Next we organized missions and multidisciplinary teams of scientists, went to sea and reported to the public on another successful field season. All of that—in less than one year!

I hope you enjoy our 2003 Annual Report.

CAPT. Craig McLean
Director, NOAA Office of Ocean Exploration


SEA CRANE
URI ONR
MYSTIC AQUARIUM

VISION AND MISSION

THE VISION

The oceans are the lifeblood of Earth. They cover more than 70 percent of the planet's surface, drive its weather, and ultimately fuel all living creatures. Throughout history they have been a vital source for sustenance, transport, commerce, growth and inspiration. Yet for all of our reliance on the oceans we have explored less than 5 percent of their breadth and depth.

Realizing the urgent need for a better understanding of this critical global resource, and in response to growing national concern over the state of the oceans, the U.S. government empowered a panel of experts in 2000 to develop a national strategy for ocean exploration. The result was the creation of a National Ocean Exploration Program (OE) in 2001 to be led by the nation's ocean agency, the National Oceanic and Atmospheric Administration (NOAA).

THE MISSION

NOAA's Office of Ocean Exploration was created to investigate the oceans for the purpose of discovery and the advancement of knowledge. NOAA's OE program signaled a turning point for this nation's ocean exploration efforts and it represents a bold and innovative approach. It infuses teams of multidisciplinary scientist-explorers with a "Lewis and Clark" spirit of discovery, then equips them with the latest exploration tools - some pioneered specifically to support OE missions. These new exploration tools are taking researchers to some of the deepest and least explored regions of the world's oceans and as a result, a more thorough understanding of the deep ocean realm is evolving.

OE's mission fits into four distinct areas:

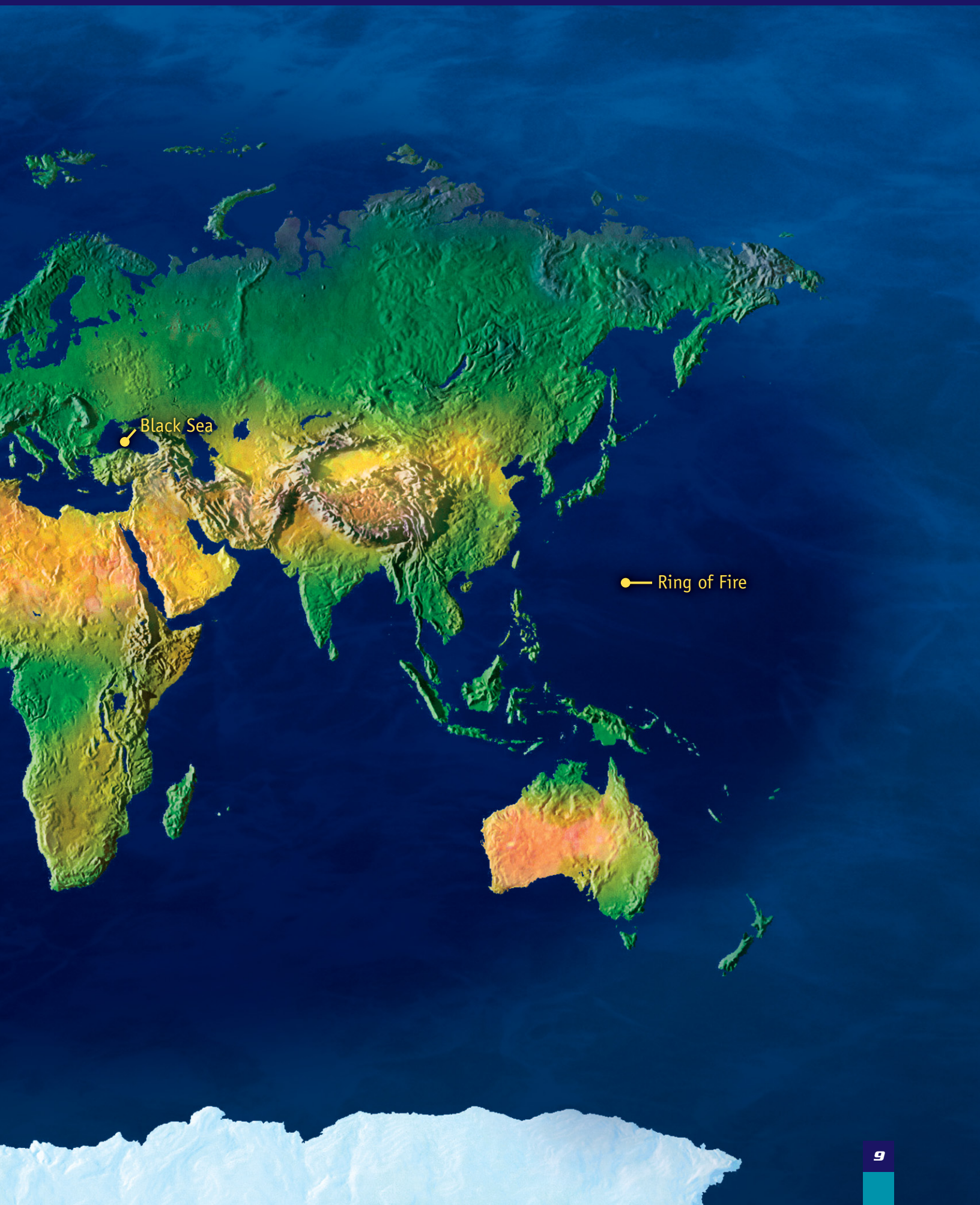
- Mapping and characterizing the physical, biological, chemical and archaeological aspects of the ocean;
- Developing a more thorough understanding of ocean dynamics and interactions at new levels;
- Developing new sensors and systems to regain U.S. leadership in ocean technology, and;
- Reaching out to the public to communicate how and why unlocking the secrets of the ocean is well worth the commitment of time and resources, and to benefit current and future generations.

OE dedicates 10 percent of its annual budget to various outreach and education activities, and is committed to working towards improved science literacy and developing the next generation of ocean explorers, scientists, and educators. By tapping into NOAA's Ocean Explorer Web site and other outreach initiatives, Americans become "citizen explorers" and connect deeply with their own instinctive fascination with the oceans.

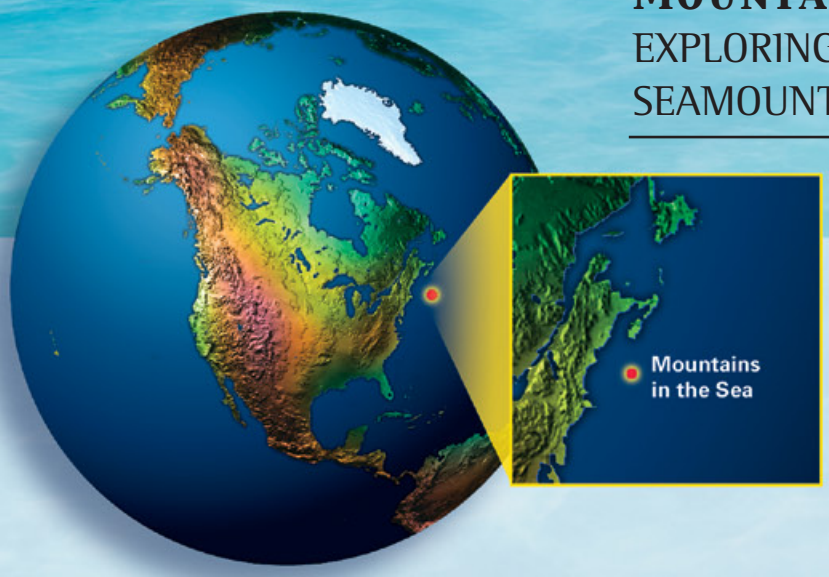
Expeditions and projects undertaken in 2003 were built on OE's previous two years of discovery-based ocean research. Results from the 2003 field season already include new maps of previously unknown ocean areas, the discovery of new marine species and habitats, and volumes of new data for scientists, natural resource managers and educators.

Please read on to learn more about the discoveries made and the new mysteries uncovered during 2003. ■

2003 Ocean Expeditions


Black Sea
Ring of Fire

Mountains in the Sea:
EXPLORING THE NEW ENGLAND SEAMOUNT CHAIN



The New England seamounts make up the longest seamount chain in the North Atlantic. They encompass more than 30 major volcanic peaks extending from Georges Bank southeast for about 1,100 km to the eastern end of the Bermuda Rise, ending abruptly with Nashville Seamount to the east northeast of Bermuda.

An interdisciplinary team of scientists (including ichthyologists, geneticists, reproductive biologists, oceanographers, and a hydrographer), educators, journalists, graduate students, and a scientific illustrator were among the few who have ever explored these seamounts. The objectives of the expedition were to map the distribution of octocorals and assess the overall diversity of seamount organisms; determine whether New England seamount octocorals are genetically distinct; examine the reproductive state and larval strategies of seamount octocorals; assess the physical impact of bottom trawling on octocoral communities and seamount biodiversity; and acquire multibeam data to produce high resolution maps of the regions studied.

The expedition took place aboard the Woods Hole Oceanographic Institution's Research Vessel (R/V) *Atlantis* from July 11 – July 19, and used the Deep Submergence Vehicle *Alvin* to explore the deep ocean.

Three seamounts, Bear, Kelvin, and Manning, were visited during the expedition. Multibeam mapping occurred on Bear and Kelvin seamount, with some maps made of areas in between the sampling sites. This cruise was the first to map and dive on Kelvin seamount.

Two *Alvin* dives were made at Kelvin and Manning and three dives conducted at Bear seamount. On each dive, the *Alvin* collected video and digital still imagery and sampled for deep-water corals and associated fauna, especially organisms living with the corals and fish inhabiting coral assemblages. Once back on the ship, each coral specimen was sampled for reproductive state and morphology of the polyps, tissue was taken for genetic analysis, associates were removed and preserved, and then the entire coral body was preserved for final identification on return to the laboratory.

A journalist from *Science Magazine* covered the cruise and wrote an article titled 'Deep Sea Mountaineering,' published in *Science Magazine* in August 2003. A reporter from *Newsday*, also participated in the cruise and submitted daily logs and images from sea to the "Our Natural World" series of the New York area *Newsday* Website.

A live question and answer session was orchestrated between students in Connecticut and scientists in the *Alvin* while the submersible was diving at 1600 meters below the surface on Bear Seamount.

The R/V *Atlantis* and DSV *Alvin* were the support platforms for the Mountains in the Sea expedition. The support ship's multibeam sonar and dynamic positioning were critical to the success of the mission.

EXPEDITION AT A GLANCE

- New England Seamounts
- July 11 – July 19, 2003
- Research Vessel *Atlantis*
- Deep Submergence Vehicle *Alvin*
- 7 Submersible Dives
- 29 hours of bottom time
- First mapping and exploration of Kelvin seamount
- Over 440 specimens collected

ACCOMPLISHMENTS

At least one new species of deep-sea coral may have been discovered, as was at least one new species of cumacean (small shrimp-like crustacean). In addition, the habitat range of several fish species was preliminarily extended through the findings of this expedition.

Co-Principal Investigator, Ivar Babb, Director of the National Undersea Research Center (NURC) at the University of Connecticut (UConn) said, "This was a very successful cruise, as more samples were collected and information obtained than we all imagined possible."

Peter Auster, science director at NURC/UConn said, "We saw approximately 18 species of deep-sea fishes, which is not many when one considers shallow water fish communities but is substantial when working in the deep sea." Auster continued, "the seven dives showed us that fish are distributed very unevenly around seamounts and there are apparent differences between seamounts. For example, very few species were seen at Kelvin Seamount but many more were observed at Manning and Bear Seamounts."

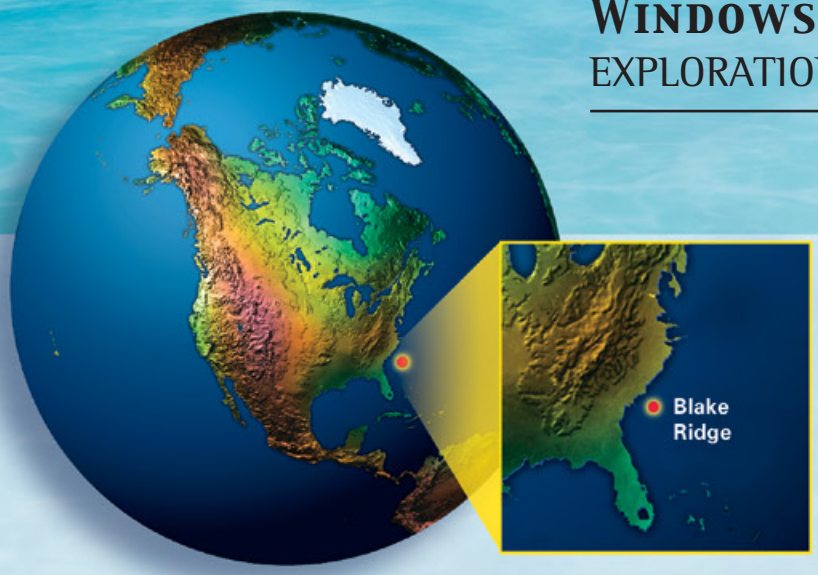
Observations suggest there are associations of some species with particular features of the seafloor landscape. Hakes and cusk eels were observed in the shelter of basalt crevices searching for prey, while halosaurs found shelter over sediment ripple features.

Scott France, professor of biology at the College of Charleston, sampled 20 different coral species for genetic sequencing on the three seamounts visited, including six black corals and one stony coral. France indicated, "These genetic diversity data can ultimately be used to estimate the amount of larval dispersal between the seamounts. For this objective, we sampled tissue from seven species found on more than one seamount."

Les Watling, the Principal Investigator of the cruise and Professor of oceanography at the University of Maine, determined the corals collected differed significantly from those seen in the canyons and on the slope off the US east coast. He also noted each coral species had its own set of associated species, such as worms or brittle stars.

Jon Moore, Assistant Professor, Florida Atlantic University, studying the biodiversity on the seamounts stated, "Photographic surveying and selective sampling during this expedition has impressively expanded our knowledge of the animals living on these seamounts." ■

WINDOWS TO THE DEEP:
EXPLORATION OF BLAKE RIDGE



A vast reserve of gas trapped in ice-like hydrate deposits and free gas that migrates up through sediments is located at Blake Ridge on the U.S. Atlantic Ocean margin, at water depths greater than 2000 meters. Where seafloor faults, salt diapirs (domes where overlying sedimentary layers are broken and uplifted by the movement of more plastic underlying rocks, such as salt or shale), and sedimentary structures disturb the gas hydrate reservoir, there is potential for development of communities that rely on chemosynthesis (synthesis of organic compounds by energy derived from chemical reactions) rather than photosynthesis as the basis of the food web. Ecological characteristics of these communities serve as indicators of composition and flux of fluids and gas within the sediments.

The goals of the *Windows to the Deep* expedition were to develop an understanding of the geological setting associated with deep-sea hydrate and gas reserves on the Blake Ridge and to locate additional methane seeps and seep communities using integrated biological, chemical, and geophysical approaches. The expedition team included scientists and students with experience in aqueous and sediment geochemistry, seep ecology, microbial ecology, hard-rock geology, seismology, geophysics, and marine hydrogeology.

The expedition was staged aboard the Woods Hole Oceanographic Institution's Research Vessel (RV) *Atlantis* from July 22 – August 3, 2003, and used the Deep Submergence Vehicle *Alvin*.

Seven *Alvin* dives were conducted to explore the biology, physics, and chemistry of seafloor methane seeps at water depths of 2,000 meters to 3,500 meters off the coast of the southeastern U.S.

Three dives on the Blake Ridge Diapir presented researchers with the opportunity to expand exploration of this known methane seep and to map the distribution of live clams, dead clams, and mussel fields in greater detail. During the dives, scientists collected samples of clam populations for studies linking clam distribution and health to the geochemistry of underlying sediments. Scientists also acquired mussel samples for histopathological studies, and used push cores to sample sediments and bacterial mats for geochemical analyses and microbial community studies based on DNA and RNA.

Windows to the Deep had an active nighttime program of SEABEAM bathymetric mapping and 3.5 kHz sub-bottom profiling. These surveys and *Alvin* dives enhanced our understanding of the ecology of methane seeps, the relationship of salt diapirs to the geology of the region and to gas hydrate dynamics, and structural features associated with the Cape Fear landslide.

ACCOMPLISHMENTS

EXPEDITION AT A GLANCE

- Blake Ridge
- July 22 – August 3, 2003
- Research Vessel *Atlantis*
- Deep Submergence Vehicle *Alvin*
- 7 Submersible Dives
- New exploration of Cape Fear Diapir, Cape Fear escarpment, Blake Ridge Diapir, and Blake Ridge
- New maps created of Cape Fear submarine slide and of diapirs inboard of Carolina Trough

The team of scientists, led by Chief Scientist Dr. Carolyn Ruppel of the Georgia Institute of Technology and Co-Chief Scientist Dr. Cindy Lee Van Dover of The College of William and Mary, accomplished diverse scientific objectives during their exploration of the Blake Ridge gas hydrates province.

Using *Alvin*, the scientists acquired a complete suite of geochemical and biological (clams, mussels, and bacterial mats) samples on the Blake Ridge Diapir, where gas hydrate had been observed at the seafloor in 2001. Geophysical imaging of the shallow sub-seafloor sediment layers at this location revealed the three-dimensional structure of the gas chimneys sustaining the cold seep chemosynthetic community. Studies combining the results of the biological, geochemical, and geophysical sampling are at the frontier of interdisciplinary research on the deep ocean environment. In this case, the integrated approach permits researchers to relate the spatial distribution of mussels, clams, and bacterial mats to the chemistry and physics of the sub-seafloor methane and fluid plumbing system.

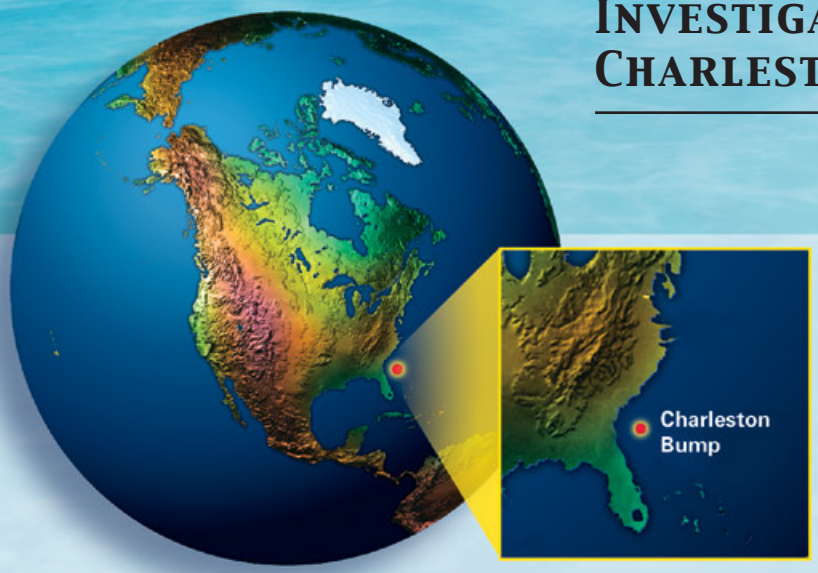
The new biological samples are also being used for focused studies. Researchers are extending their work on viruses infecting mussels, linking clam reproduction to sediment geochemistry, identifying new species, and using genetic techniques to characterize microbial populations.

With seafloor imaging tools available on the *Atlantis*, the researchers compiled the most complete map ever produced of the Cape Fear submarine slide, the largest such slide on the U.S. Atlantic margin and a feature whose origin has long been linked to the presence of gas hydrates in the sediments. "This new map has already revised our understanding of the extent and nature of this slide and of other submarine geo-hazards related to gas hydrates," said Ruppel.

The combination of comprehensive, high-resolution seafloor bathymetric surveys, extensive subsurface profiling, and seafloor ground-truth observations with *Alvin* allowed researchers to modify criteria used to predict the location of chemosynthetic communities at Blake Ridge and similar seafloor settings. As Ruppel noted, exploration-based research *always* increases our understanding of the deep-sea environment. "We are engaged in planetary exploration, where the planet is Earth," she said.

The expedition was exceptional not only in its scientific scope, but also in its impact on the 16 current or recently graduated students who participated. Eleven students visited the seafloor in *Alvin*, and the students often took the lead role in data acquisition and analysis. During *Alvin's* ascent from the seafloor, one student said, "I thought about how far I was from where I grew up…and how lucky I was to have this experience." ■

Investigating the Charleston Bump



Off the coast of South Carolina and Georgia exists a unique feature called the Charleston Bump, which rises off the surrounding Blake Plateau from 600 meters deep to a depth of about 370 meters. The rocky, erosion-resistant Charleston Bump impedes the flow of the Gulf Stream, deflecting it offshore and creating a zone of gyrating eddies and swift, narrow currents. The combination of rocky, high-relief bottom and strong currents creates a complex habitat consisting of scour depressions, mounds of deep-sea corals and rubble, and steep slopes that are deeply undercut with extensive caves.

The investigation of the Charleston Bump was staged from the Harbor Branch Oceanographic Institution's (HBOI) Research Vessel *Seaward Johnson*, from August 1-14, 2003, and was funded through NOAA's Office of Ocean Exploration. Scientists from the Marine Resources Research Institute at the South Carolina Department of Natural Resources and the University of South Carolina led the expedition.

During the 15 days at sea, researchers investigated how fishes and invertebrates adapt to the variety of bottom habitats, and how they tolerate the strong and shifting currents. They also sought to find new and unique species. Much of this work was conducted using HBOI's *Johnson-Sea-Link II* submersible, which is outfitted with digital video, still cameras and other instruments to record information about the surrounding waters. The submersible collected samples of rocks and sediments, as well as specimens of fishes and invertebrates such as sponges and deep-water corals. Additionally, instruments were deployed to measure temperature, salinity, oxygen content, and current speed and direction throughout the water column. This information is used to describe the water column and dynamics of water flow at the Charleston Bump and to characterize the habitat of the organisms collected.

An "Open House" took place immediately following the cruise, on August 15, as the vessel was docked in Charleston, SC. Hundreds of students from nearby schools in grades 5-12 were able to tour the vessel. They had the opportunity to see the *Johnson-Sea-Link II* submersible and several specimens collected during the Charleston Bump cruise as the scientists acted as tour guides and answered questions about their work and life at sea. A second component of this day was a nearby "Ocean Education Fair" where NOAA's Office of Ocean Exploration, the South Carolina Aquarium, Project Oceanica, the North Carolina Museum of Natural Sciences, and the South Carolina Sea Grant set

up exhibits to tell students about their work, engage them with brief educational activities, and hand out materials.

ACCOMPLISHMENTS

During the cruise to the Charleston Bump, 14 submersible dives, down to depths of 600 meters, were completed. Scientists encountered a great variety of habitats during these dives, each inhabited by different forms of life. "The largest bottom-dwelling species of bony fish, wreckfish and red bream, tend to occupy habitats providing a large amount of protected space, such as caves and overhangs," said David Wyanski, a fish biologist with the South Carolina Department of Natural Resources. "Away from areas of steepest relief, we noted fauna that were adapted to lower relief habitats. In areas with manganese-phosphorite rubble or low-relief limestone rock interspersed with patches of sand, we noted smaller fish species, often associated with sponges, corals or rock formations that conferred protection," he said, continuing with his assessment of species distribution in this unique environment.

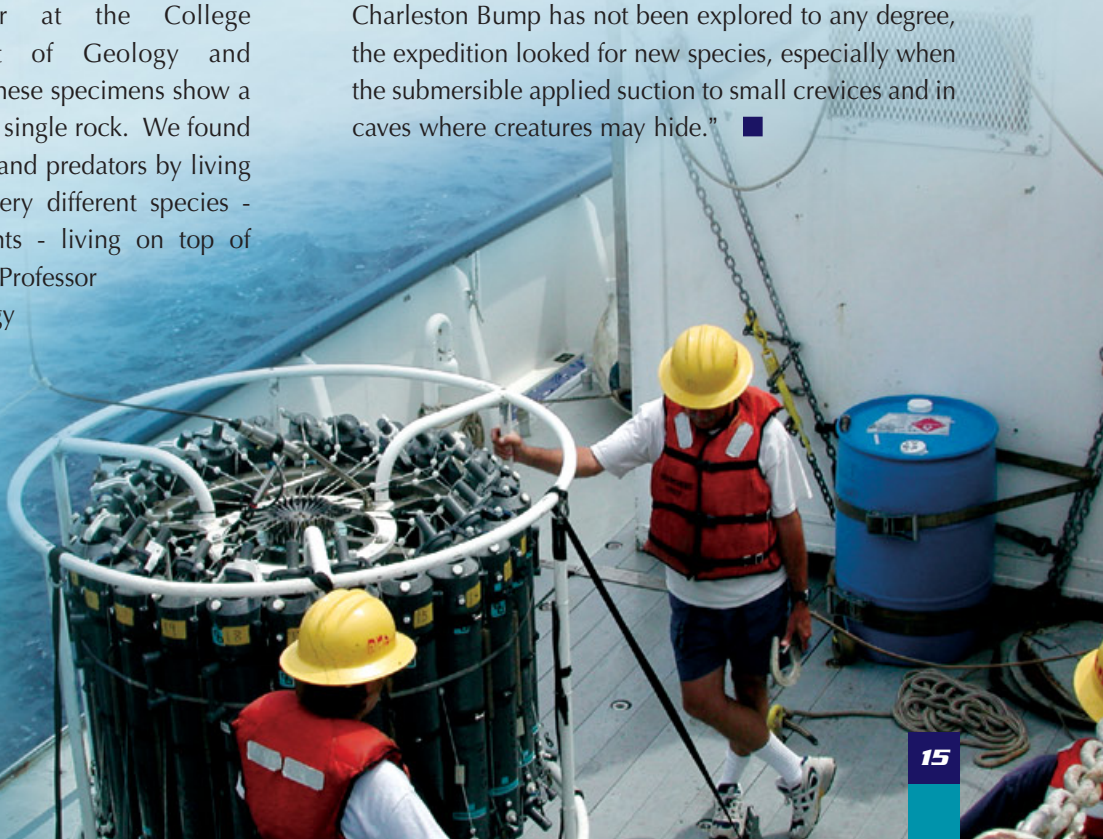
"We collected more than 20 'living rocks,' " said Leslie Sautter, Associate Professor at the College of Charleston's Department of Geology and Environmental Geosciences. "These specimens show a wide range of invertebrates on a single rock. We found organisms escaping the current and predators by living on the rock undersides, and very different species - those better adapted to currents - living on top of the same rocks." Steve Stancyk, Professor of Marine Science and Biology at the University of South Carolina and Co-Principal Investigator of the cruise will be identifying the organisms collected.

EXPEDITION AT A GLANCE

- Charleston Bump
- August 1-14, 2003
- Research Vessel *Seward Johnson*
- *Johnson-Sea-Link II* submersible
- 14 Submersible Dives
- "Open House" in Charleston, SC
- Specimen collection
- Water flow dynamics

"The links between patterns of water flow and the types of organisms that live in each flow 'regime' have been studied in habitats such as coral reefs and seamounts in the North Atlantic, but seldom have they been investigated in deep water, and never at the Charleston Bump," said Stancyk. An example of such a link was observed during one of the dives, where a fan-like sponge had created a micro-habitat on its down-current side by reducing water current velocity, and thereby causing the deposition of sediment. The pile of sediment was collected with the suction sampler on the submersible and will be examined to see if invertebrate abundance is greater in the sediment pile as compared to sediments in adjacent areas with higher currents.

"Under such harsh conditions, one might expect to find a dearth of marine life," said George Sedberry, senior marine scientist at the South Carolina Department of Natural Resources. "Yet, a submersible visit to the bottom revealed three-foot long wreckfish, large barrelfish and bizarre forms of corals and sponges bending into the current to scoop up the sparse plankton drifting in the Gulf Stream. Because the Charleston Bump has not been explored to any degree, the expedition looked for new species, especially when the submersible applied suction to small crevices and in caves where creatures may hide." ■



LIFE ON THE EDGE:
EXPLORATION OF UNIQUE REEF OUTER SHELF & SLOPE HABITATS OFF THE CAROLINAS

Many marine habitats have been overlooked or only cursorily examined. Deep study areas such as those off the Carolinas, between 100-1000 meters, are important frontiers, offering a transition from the continental shelf to the true deep sea. Relative to the continental shelves of the U.S. and Gulf of Mexico, transition areas are less well studied because the bottom topography is extremely rugged and/or overlain by extreme currents. As a result, non-conventional sampling methods must be incorporated into mission design.

The unique and productive habitats off of the Carolinas were explored through a multidisciplinary partnership between NOAA's Office of Ocean Exploration (OE), the U.S. Geological Survey (USGS), University of North Carolina – Wilmington, North Carolina Museum of Natural Sciences, NOAA Systematics Laboratory, NAPRO Communications, and Harbor Branch Oceanographic Institution (HBOI).

The expedition was staged from the HBOI Research Vessel (R/V) *Seward Johnson*, between August 16 and 27, using the *Johnson-Sea-Link II* manned submersible and a Panther remotely-operated vehicle (ROV). The expedition was sponsored by OE as part of its mission to investigate the oceans for the purpose of discovery and the advancement of knowledge. Project Principle Investigators were S.W Ross (lead, UNCW), K.J. Sulak (USGS), M.S. Nizinski (NMFS), and E.D. Baird (NCSM).

Scientists completed a 12-day voyage to study the region's poorly known deep-reef habitats, including deep *Lophelia* coral bank habitats.

Life on the Edge included locating, profiling, and defining habitats, developing a holistic concept of community structure and function, examining the use of hard bottom habitats as nursery areas for economically important fish species, evaluating boundaries and candidate habitats for a proposed Marine Protected Area and confirming the true nature of the site known as the "Snowy Wreck."

Plans included sharing the expedition with the public through an array of outreach partners including the North Carolina Museum of Natural Sciences.

An "At-Sea Media Day" was held August 20 so expedition scientists could report their findings to and answer questions for the media. Scientists and explorers led tours on board the research vessel to demonstrate the technology that enabled this expedition and to explain discoveries they made.

ACCOMPLISHMENTS

The diverse team of scientists and educators was successful in exploring, comparing, and contrasting the closely associated ecosystems of the outer shelf hard grounds and midslope deep coral *(Lophelia)* banks off the Carolinas.

Dr. Steve Ross of UNC-Wilmington, described the need to study these habitats, "Overlain by extreme currents and difficult to sample using conventional surface gear, these deep habitats have been poorly-known. When we sampled deep reefs we looked closely at the data and saw large communities of fish otherwise thought to be rare. If we find that deep-sea corals are primary habitats for these rare fish communities, we'll need to act soon to protect those habitats and reefs from further damage."

These sampling methods included a variety of surface and mid-water sampling, including tucker trawls, plankton nets, neuston netting, night light, rod and reeling and dip netting. Additionally, a Remotely Operated Vehicle (ROV) investigation and daily manned submersible (*Johnson SeaLink II*) were deployed for the purpose of investigation.

The submersible and surface investigations were undertaken at four primary target sites along the outer shelf and slope of the Carolinas. Undersea operations comprised 17 submersible dives and one ROV dive.

EXPEDITION AT A GLANCE

- Carolinas
- August 16-27, 2003
- R/V *Seward Johnson*
- *Johnson-Sea-Link II* Submersible, Panther ROV
- 17 Submersible Dives
- 1 ROV Dive
- 1st collection of invasive Lionfish via submersible
- Confirmed "Snowy Wreck" Shipwreck
- Media Interacted with Scientists

During the dives, scientists took hundreds of underwater digital still images to document reef habitats and the fish and invertebrate fauna. Scientists noted significant range extensions for several species of fish indigenous to the Caribbean.

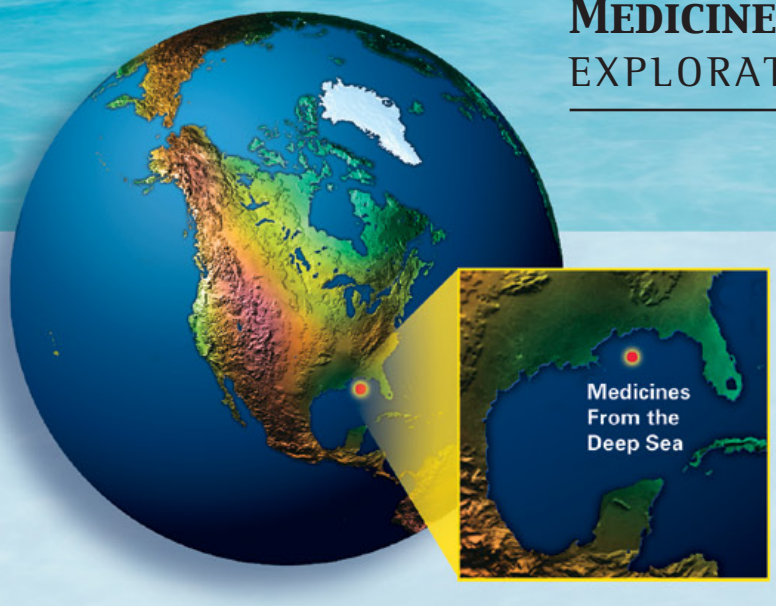
Surface sampling operations were conducted at more than 50 surface stations and 21 midwater sampling stations using several types of equipment. At one surface station, scientists were excited to capture close-up video imagery of spawning behavior of one flying fish species they believe had never previously been documented.

In addition to collecting samples and imagery, scientists undertook a large number of fathometer surveys. The resulting digital image files pinpoint areas of undersea topography documenting deep-coral reefs that may be the subjects of future explorations.

With video gathered from the ROV, scientists confirmed for the first time that the seafloor target known as the "Snowy Wreck" is indeed a shipwreck of a steel-hulled, 120-foot long vessel that is largely intact.

NOAA scientist Dr. Martha Nizinski spoke about the mission's teamwork and their drive to succeed, "The mantra of our mission was 'Make this cruise count'. Every valuable piece of information we can glean from our samples will be incorporated into scientific, peer-reviewed manuscripts." ■

MEDICINES FROM THE DEEP SEA:
EXPLORATION OF THE GULF OF MEXICO



Deep-water marine habitats are a relatively untapped resource in the search for new medicines. Virtually no drug discovery research had targeted the deep-water reef and hard-bottom communities in the Gulf of Mexico, and, in particular, the micro-organisms living in these communities.

This project explored untapped sources for potential new drugs that will be applied over the long-term in the study, and treatment of human diseases, including cancer, infectious diseases, diseases of the immune system, cardiovascular disease and central nervous system disorders.

Sailing from St. Petersburg, Florida, scientists from Harbor Branch Oceanographic Institution (HBOI) partnered with NOAA's Office of Ocean Exploration (OE), Sonsub Inc., C&C Technologies Inc., and NOAA's Office of Coast Survey in a 12-day search for new "medicines from the deep sea."

The mission was staged from the 274-foot NOAA ship *Ronald H. Brown* using the Sonsub Inc. remotely-operated vehicle (ROV), *Innovator*, a heavy-duty industrial ROV to collect specimens and document the habitats explored. In their quest to identify new medicines, scientists focused on collecting and studying marine organisms found in deep rocky habitats along the shelf edge from southwestern Florida to Alabama.

The exploration objectives for the Medicines from the Deep Sea mission sought to advance understanding of the northern Gulf of Mexico by conducting "marine life inventories" of both vertebrates and invertebrates. Scientists also located and mapped deep-water corals, discovered new ocean resources, and promoted ocean science through education and outreach activities.

OE's national education coordinator and a Florida high school teacher-at-sea provided a strong educational component to the mission. Their efforts included lesson plan development for grades 6-12, mission logs and interviews, and post-cruise presentations.

Expedition scientists held a "Port Call" day on September 8, to discuss their pre-cruise expectations and answer questions from the media. Scientists and explorers led tours on board the NOAA ship *Ronald H. Brown* to demonstrate the technology that enabled this expedition and to discuss mission objectives and potential discoveries.

ACCOMPLISHMENTS

Decommissioned oil rigs, towers of coral that rise from the ocean floor, and a limestone ledge that 15,000 years ago was the shoreline of Florida's west coast were just a few of the targets the scientific team explored during the mission in the northern Gulf of Mexico.

"Basically no research had been conducted on the biomedical potential of the Gulf of Mexico deep sea resources," said John Reed, Chief Scientist for HBOI's Division of Biomedical Marine Research (DBMR).

EXPEDITION AT A GLANCE

- Gulf of Mexico
- September 8-19, 2003
- NOAA ship *Ronald H. Brown*
- Sonsub *Innovator* ROV
- 22 ROV Dives
- 5 SCUBA Dives
- Industry ROV used for scientific investigation
- New species discovered
- New bioactive compounds under investigation

The Deep Sea Medicines mission was a cooperative effort between scientists and industry. Scientists used the ROV *Innovator*, which is owned and operated by Sonsub Inc. based in Houston, Texas. The ROV is often operated in support of the offshore oil industry and can dive to nearly 10,000 feet. The *Innovator* was specially configured with a set of new tools which were fabricated to support a series of scientific expeditions based from the NOAA ship *Ronald H. Brown.* These tools maximized the ROV's capability to collect scientific data and marine specimens.

During the expedition, scientists used the ROV to collect samples, record 585 high-quality underwater digital still images and 69 hours of video to document the fish, invertebrate fauna, and reef habitats.

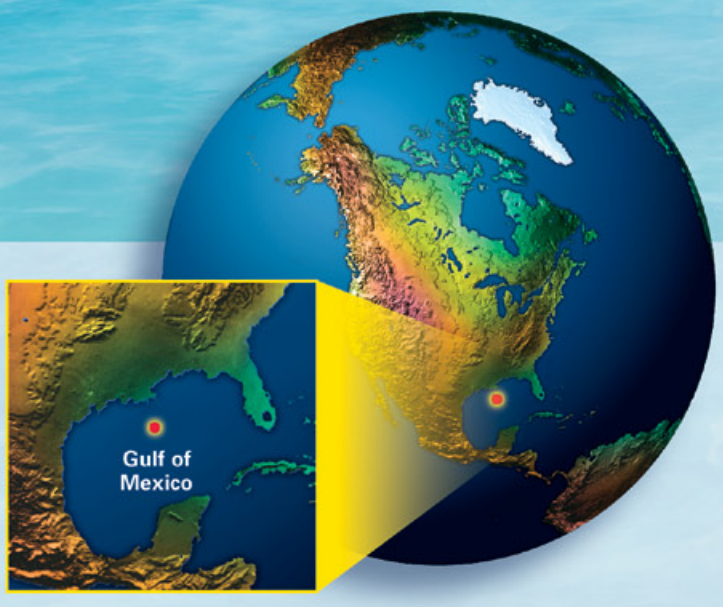
In addition to the samples and photographs, scientists used the ship's SEABEAM mapping system to gather bathymetric data and subsequently developed high-resolution topographic maps of five sites. These high-resolution maps were used to identify the primary target locations to dive the ROV.

Prior to the cruise, Dr. Shirley Pomponi, HBOI's Vice President and Director of Research, was confident of new discoveries, "Because so much of the Gulf remains unexplored, I expected to find new organisms that we had never encountered before on any of our other trips."

Preliminary results suggest the cruise exceeded expectations of the Principal Investigators, Dr. Pomponi, Dr. Amy Wright, and John Reed. At least one new species of sponge was discovered, and chemical analysis indicates novel compounds were present in many of the samples collected. Among other achievements, scientists brought up specimens of the sponge *Forcepia* to continue research on compounds showing promise in the treatment of pancreatic cancer.

Though it may be years before we determine if any of these compounds will directly benefit human health, sample testing and the search for new samples must continue if we are to discover new medicines from the sea. ■

Northern Gulf of Mexico Deep-Sea Habitats



The presence of deep-sea corals in the Gulf of Mexico has been known for several decades, yet little work has been focused on understanding their basic biology, functional ecology, distribution and abundance. Some of these questions were explored through a NOAA-sponsored expedition aboard the NOAA ship *Ronald H. Brown*, using an industry-standard ROV, the *Innovator* from Sonsub of Houston. During this 12-day expedition, deep-sea coral habitats were investigated by three discrete groups of scientists: the Marine Conservation Biology Institute, NOAA's Flower Garden Banks National Marine Sanctuary, and the University of Alabama.

The expedition provided an opportunity for a scientist from Marine Conservation Biology Institute (MCBI) to field-test the *Deep-sea Coral Collection Protocols*, a document prepared by a panel of experts from several institutions involved in collecting, preserving, and analyzing deep-sea corals. The goal of the *Protocols* is to improve our national capacity to document deep-sea coral diversity. MCBI also hoped to document the way Gulf of Mexico deep-sea corals provide habitat to associated species. Deep-sea corals are designated "essential fish habitat" in the Pacific, where they enjoy legal protection under the 1996 Magnuson Stevens Fishery Conservation and Management Act.

A group of scientists from NOAA's Flower Garden Banks National Marine Sanctuary continued their efforts to biologically and geologically characterize the Flower Garden Banks, and other deep-water reef communities of the Northwestern Gulf of Mexico. On this cruise, they were primarily interested in classifying those representative organisms appearing to be "signature" species that help define the biological communities. The goals of the ongoing efforts are to determine the linkages between the biological communities and assess regulatory and management needs of the reefs and banks of the Northwestern Gulf of Mexico.

Finally, a deep-sea corals group, led by scientists from the University of Alabama, explored the occurrence and ecology of deep-sea corals, specifically *Lophelia pertusa,* which is potentially widely distributed and associated with very site-specific conditions conducive to colonization and growth. Unlike the large *Lophelia* reefs found in the South Atlantic Bight, the information available indicates the colonies in this region exist as scattered thickets anchored on hard carbonate substrate found in association with relict hydrocarbon seeps. If so, scientists may be witnessing the early stages of *Lophelia* coral reef development. Given the expansion of the oil and gas industry in the northern Gulf of Mexico, it is critical that these areas are located, mapped, and characterized, and that comprehensive

efforts are undertaken to learn more about their biology and ecological function – the foundation for developing sound management strategies to protect these fragile resources.

EXPEDITION AT A GLANCE

- Northern Gulf of Mexico
- September 21 – October 2, 2003
- NOAA ship *Ronald H. Brown*
- 3 projects
- Deep-sea corals and deep-water reef communities explored
- 12 ROV dives
- Private industry ROV used

ACCOMPLISHMENTS

Thanks to the cooperation of a multidisciplinary group of scientists on board the research vessel, 12 ROV dives were conducted successfully, involving more than 59 hours of bottom time. Several hundred specimens associated with deep-sea communities were also collected for further study. This specimen bounty included various sponges, many algal species, more than 80 species of invertebrates, 21 coral species, and various fishes, as well as numerous geological samples.

"We explored several sites," explains Sandra Brooke from the Oregon Institute of Marine Biology and Co-Principal Investigator of the deep-sea coral group, "and each had a very distinct dominant fauna; one was predominantly *Lophelia* colonies, another large gorgonian bushes, and a third was abundantly colonized by several unidentified species of anemone. We are still in the process of discovering the extent and nature of these hardbottom communities but as always, the further we investigate, the more questions arise."

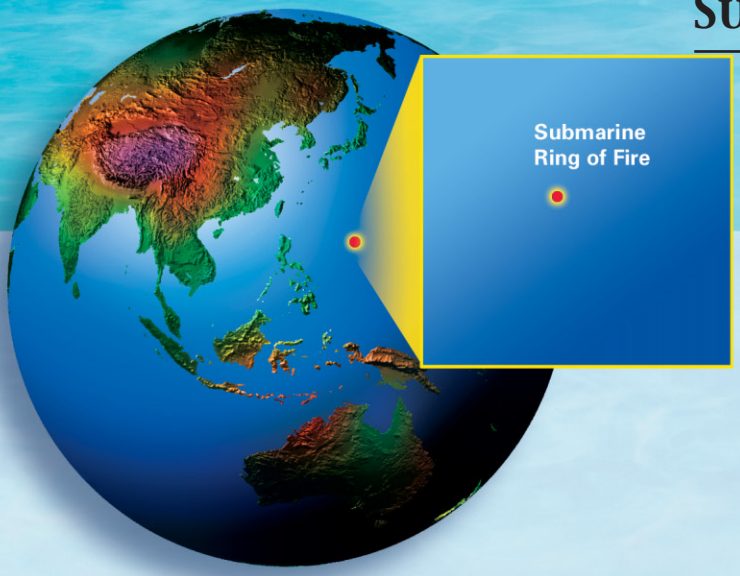
There were several new discoveries made regarding the species residing in the Northernwestern Gulf of Mexico. "These collections resulted in two new (undescribed) species of algae, and multiple range extensions for fish and invertebrates previously unknown from this part of the Gulf of Mexico," said an excited G.P. Schmahl, Chief Scientist of the Flower Garden Banks National Marine Sanctuary.

"We discovered two new species of habitat forming deep-sea corals on this trip, but one of the very exciting finds was an organism with the branching morphology and axis of a gorgonian but the dermis of a sponge," said Peter Etnoyer, Principal Investigator from Marine Conservation Biology Institute. "One might be inclined to suspect an encrusting sponge on a black coral's axis, but we documented several of this particular species in more than one place."

Additionally, deep-sea coral habitat functions were clearly evident during this expedition. "We found excellent documentation of this at 1500 feet," said Etnoyer, "where we found a large field, several hundred meters long, of the Primnoid coral *Callogorgia americana delta*. The colonies were covered with Cat Shark (Family Scliorhinidae) egg cases. A single colony was home to as many as a dozen egg cases, and cases adorned more than half the colonies."

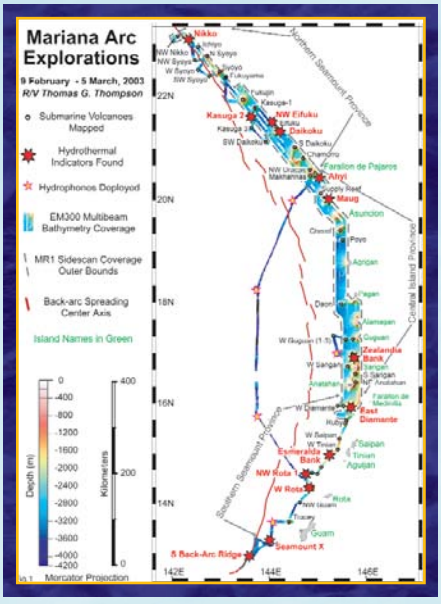
Following the cruise, students and teachers near the ship's port in Gulfport, MS were able to tour the ship and see live deep-sea crabs, corals, sponges, and other invertebrates, and learn about the diversity of deep-sea corals and deep-reef communities and their significant ecological role in the Gulf of Mexico habitats. ■

Submarine Ring of Fire



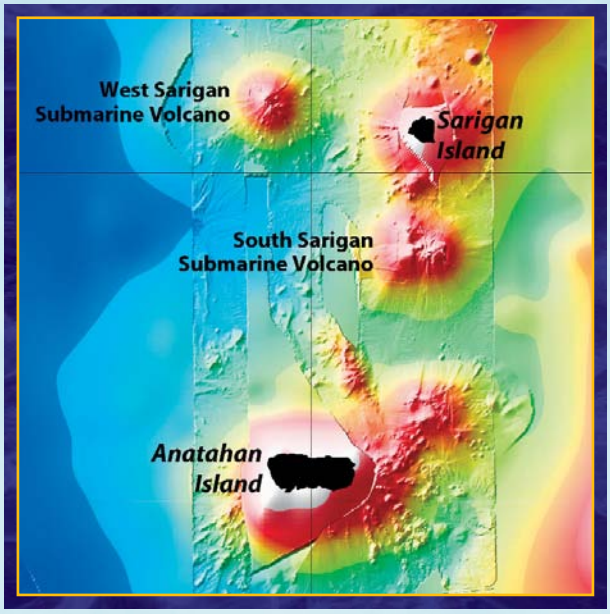
The Mariana and Volcano Arcs lie almost entirely within the U.S. Exclusive Economic Zone (EEZ) of the combined Territory of Guam and the Commonwealth of the Northern Mariana Islands. Exploratory mapping and sampling of the Mariana Arc have been ongoing since the 1960s. This is truly a frontier area of the U.S. EEZ for ocean exploration. Volcanic activity is frequent and widespread along the Mariana Arc.

The 2003 Submarine Ring of Fire expedition on the University of Washington R/V *Thomas G. Thompson* left Apra, Guam on February 9 and returned there on March 5, after making the first systematic survey of hydrothermal activity along the Mariana and southernmost volcano intraoceanic volcanic arcs.



Three primary exploration goals included mapping all of the major submarine volcanoes of the volcanic arc from Guam to the juncture of the Mariana and Volcano Arcs using high-resolution side-scan sonar and multibeam systems, conducting a reconnaissance survey of hydrothermal activity along the arc using a Conductivity-Temperature-Depth (CTD/rosette) system to map and sample hydrothermal plumes, and deploying an array of five autonomous hydrophones in the back-arc basin to monitor acoustic signals.

The expedition mapped about 5,200 square nautical miles with the MR1 towed side-scan/bathymetric mapping system and about 8,100 square nautical miles with the *Thomas G. Thompson*'s hull-mounted EM300 multibeam system. At a survey speed of nine knots, the MR1 and hull-mounted multibeam data provided a rapid high-resolution duet for surveying large areas of seafloor. Sampling of the water column during the CTD stations yielded 3,055 samples for chemical analyses of dissolved and particulate hydrothermal tracers. Five hydrophone moorings deployed at intervals along the arc recorded data until their recovery in September 2003.



ACCOMPLISHMENTS

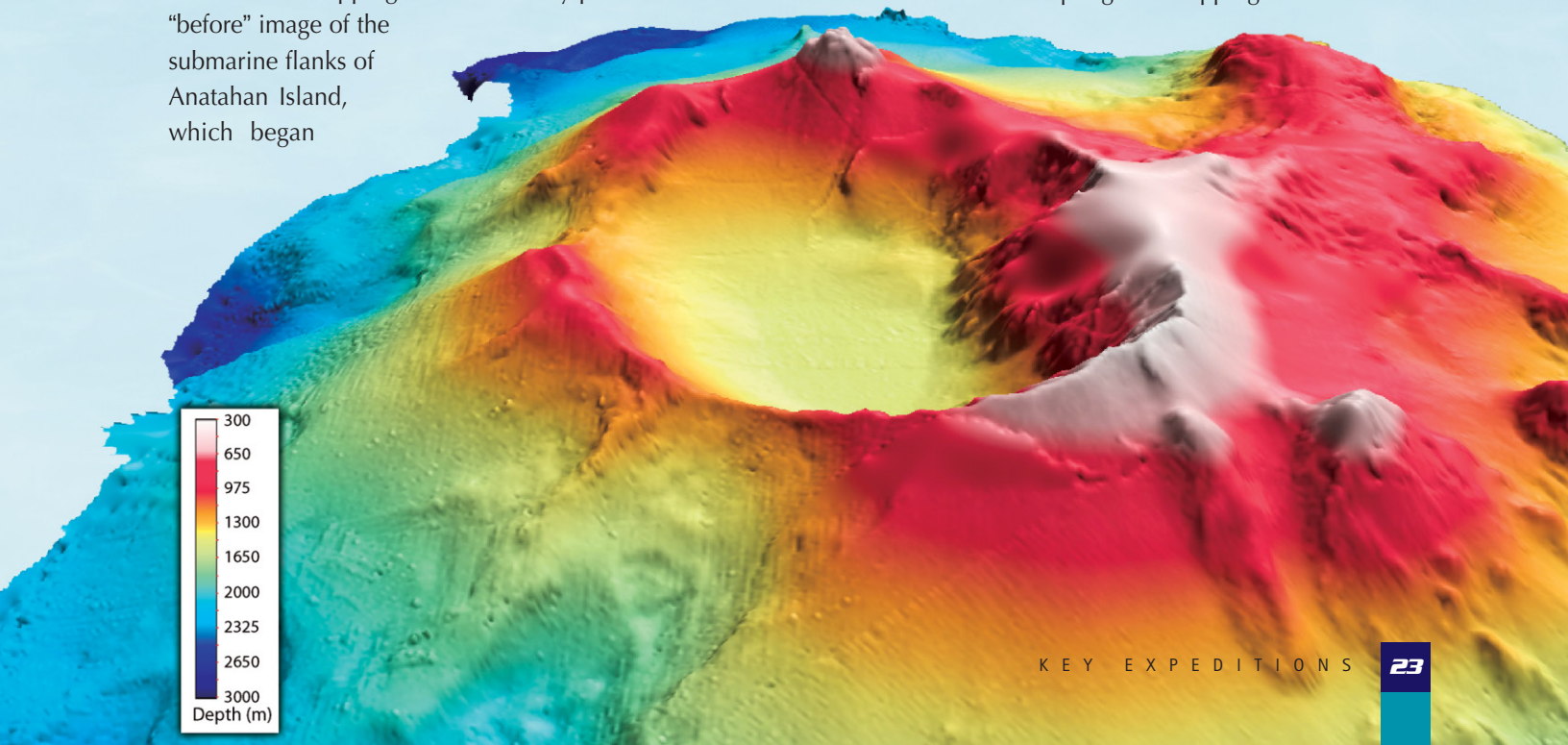
EXPEDITION AT A GLANCE

- Mariana and Volcano Arcs
  February 9 – March 5, 2003
- Research Vessel *T. G. Thompson*
  Mapped 13,300 Square Nautical Miles
- Discovered hydrothermal systems
- Deployed hydrophones
- Obtained Images before eruption

Evidence for active hydrothermal venting was found at 11 submarine volcanoes, including two sites on the southern back-arc spreading center. Three of the seven volcanoes suspected of historical volcanic activity are currently hydrothermally active - Nikko, Ahyi, and Esmeralda Bank. Preliminary analyses of the data sets have already yielded important discoveries including the large range of chemical variability in the plumes, the ubiquity of giant sediment waves in the volcaniclastic sediments of the flanks of some of the islands and submarine volcanoes, and the presence of a robust hydrothermal signal within the caldera of Maug Islands, a volcano thought to have been dormant. "A notable discovery was that submarine volcanoes of the Mariana region are much more active than previously suspected," said Chief Scientist Bob Embley. "Associated vents appear to produce chemically distinct plumes raising the likelihood of discovering new species and associations of chemosynthetic animal communities."

More than 50 submarine volcanoes were mapped with stunning new clarity and 10 active hydrothermal systems were discovered and two confirmed at 12 sites. The mapping also fortuitously provided a "before" image of the submarine flanks of Anatahan Island, which began erupting for the first time in human history on May 10, 2003. The survey around the flank of the island made three months before the eruption shows features indicative of geologically young submarine activity. Ridges extending southeast into deeper water from the southeastern flank of Anatahan are probably geologically young submarine lava flows. Data from the array of hydrophones deployed on the expedition and recovered in September 2003 by a Korean research vessel revealed precursor waterborn seismic waves prior to the eruption — data not recorded on seismometers on the islands.

The Anatahan eruption and the presence of the hydrothermal system at Maug, both formerly considered dormant volcanoes, underscores the need for more information about the state and character of these and other submarine volcanoes in the U.S. EEZ. The planned 2004 expedition will bring a remotely operated vehicle to some of these newly discovered sites to conduct sampling and mapping. ■

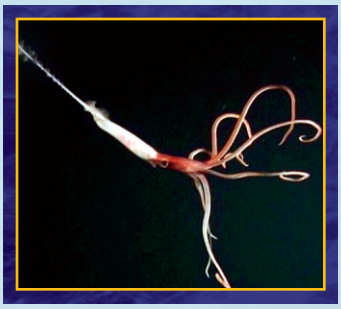


Exploring the Northwestern Hawaiian Islands

A large percentage of all U.S. coral reefs are in the Northwestern Hawaiian Islands (NWHI), a remote chain of small islands and atolls stretching 1,200 nautical miles northwest of the main Hawaiian Islands. The area's deep-sea coral beds and seamounts were explored through a multidisciplinary partnership between NOAA's Office of Ocean Exploration (OE), Hawaii Undersea Research Laboratory (HURL), University of Hawaii at Manoa, Hawaii Pacific University, National Marine Fisheries Service, National Geographic Television, and Woods Hole Oceanographic Institution.

The expedition was staged from University of Hawaii's Research Vessel (R/V) *Kai'imikai-o-Kanaloa* (Heavenly Searcher of the Seas), between September 3 and November 5, using the Pisces IV and V manned submersibles, a remotely operated vehicle (RCV-150), and a seafloor mapping sonar system. The expedition was sponsored by NOAA, as part of its mission to investigate the oceans for the purpose of discovery and the advancement of knowledge.

Scientists completed a 64-day voyage to the remote NWHI where they studied the region's virtually unexplored deep-sea corals, submarine canyons, ridges and seamounts.



Exploration included: visiting unexplored seamounts where data indicates oceanic productivity is highest in the island chain and supports unknown fish and precious coral assemblages; surveying submarine landscape of endangered Hawaiian monk seal for their habitat and fish community with specific attention to seal prey and their association with precious corals; exploring the roles of submarine canyons as hot spots of benthic production; studying the reproductive biology and genetics of deep-sea precious corals; and mapping and sampling precious coral beds and seamount deep-sea coral communities.

Plans included sharing the expedition with the public through an array of outreach partners including National Geographic Television.

A "Port Call" day was held November 6th so expedition scientists could report their findings to and answer questions from media. Scientists and explorers hosted tours for media and for area students on board the research vessel to demonstrate the technology supporting this expedition and the discoveries made. Additionally, ocean-related organizations participated in an "Ocean Education Fair," for visiting students and teachers.

ACCOMPLISHMENTS

The multidisciplinary group of scientists on this mission accomplished a wide variety of scientific objectives, explored and surveyed new territory and discovered new species and new data about previously known species.

EXPEDITION AT A GLANCE

- Northwestern Hawaiian Islands
- September 3 – November 5, 2003
- Research Vessel *Kai'imikai-o-Kanaloa*
- Pisces IV and V Submersibles, RCV-150
- 43 Submersible Dives
- 2 Legs, 4 Projects
- Discovered new species, genera
- Sighted Monk Seal at 534 meters
- Students and Media Interacted with Scientists

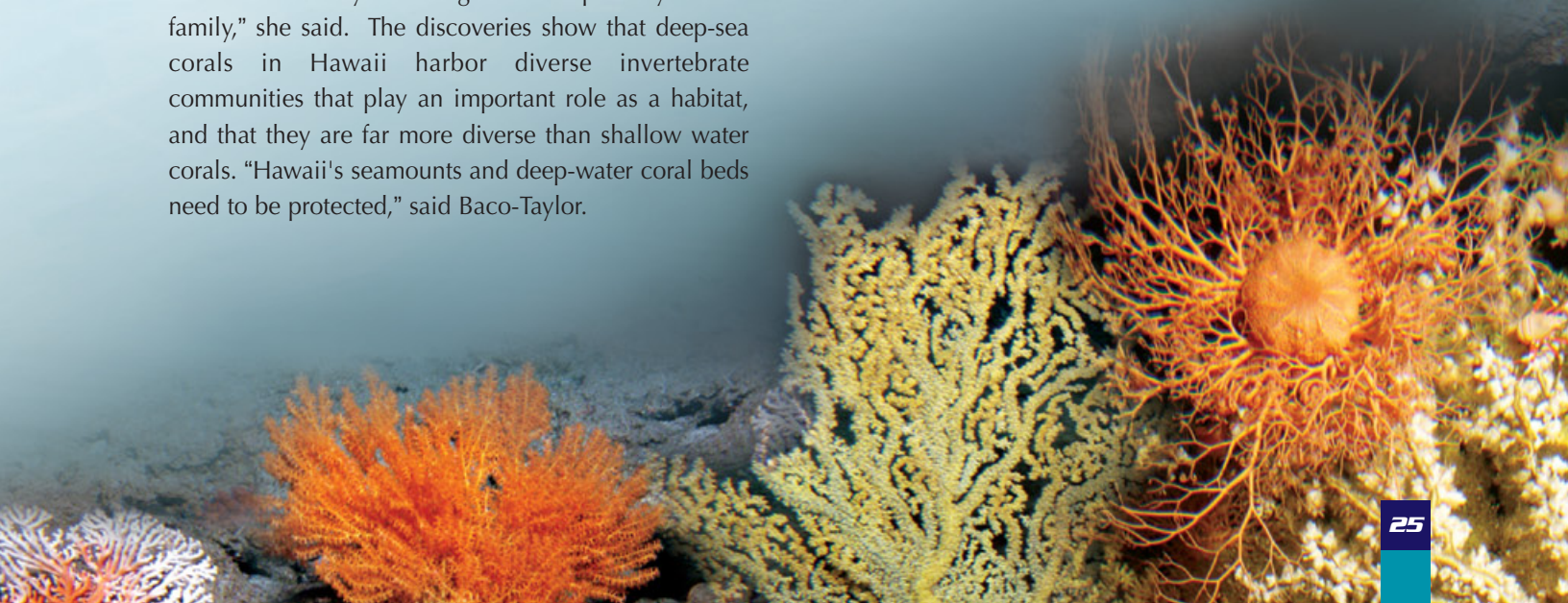
Amy Baco-Taylor of Woods Hole Oceanographic Institution studied the reproductive biology and genetics of deep-sea precious corals. "We made exciting discoveries," she said, "including four new coral beds, gold corals found spawning in the sample jars on the surface, and beds with juvenile precious corals — something we haven't observed in the Main Island coral beds."

HURL scientists Chris Kelley and John Smith, and Smithsonian scientist and curator Stephen Cairns, joined Baco-Taylor in surveying bottom-dwelling invertebrates, near-bottom fishes and deep-water corals on seamounts — undersea mountains. In the first explorations of the NWHI below precious coral depths, the scientists saw incredibly dense, high biomass coral and sponge communities at 1500-1800 meters, with sponges measuring one to three meters across.

"We discovered at least 16 new species of corals including at least two new genera," said Baco-Taylor. "At least one new crinoid (sea lily) was discovered, which is certainly a new genus and possibly a new family," she said. The discoveries show that deep-sea corals in Hawaii harbor diverse invertebrate communities that play an important role as a habitat, and that they are far more diverse than shallow water corals. "Hawaii's seamounts and deep-water coral beds need to be protected," said Baco-Taylor.

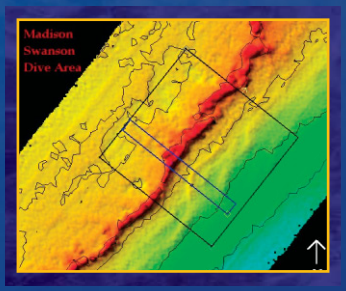
Craig Smith of the University of Hawaii at Manoa, and Eric Vetter of Hawaii Pacific University studied submarine canyon and scavenger communities. Canyons are common along slopes of submerged seamounts, but have not been well explored. During dives in canyons off Nihoa Island and Maro Reef, scientists observed a remarkable abundance and diversity of life, demonstrating that canyons are biodiversity "hotspots." "The results met our expectations that submarine canyons appear to have more diversity than areas outside canyons," said Vetter. "The abundance of those organisms increased with depth rather than decreased as one might expect." Vetter also described a rare sighting of what could be a "False Cat" shark.

Frank Parrish, a fishery biologist with NOAA's Pacific Island Fisheries Science Center, investigated how endangered Hawaiian monk seals use habitats for hunting and protection. He surmised deep-sea corals were the reason seals clustered at certain places, but observed no monk seals near those corals. Scientists on the expedition's next project were surprised and pleased to document the first known association between deep-sea corals and monk seals when a tagged monk seal suddenly peered into their submersible's view port near a collection of gold corals more than 500 meters deep.



Mapping our Uncharted Oceans

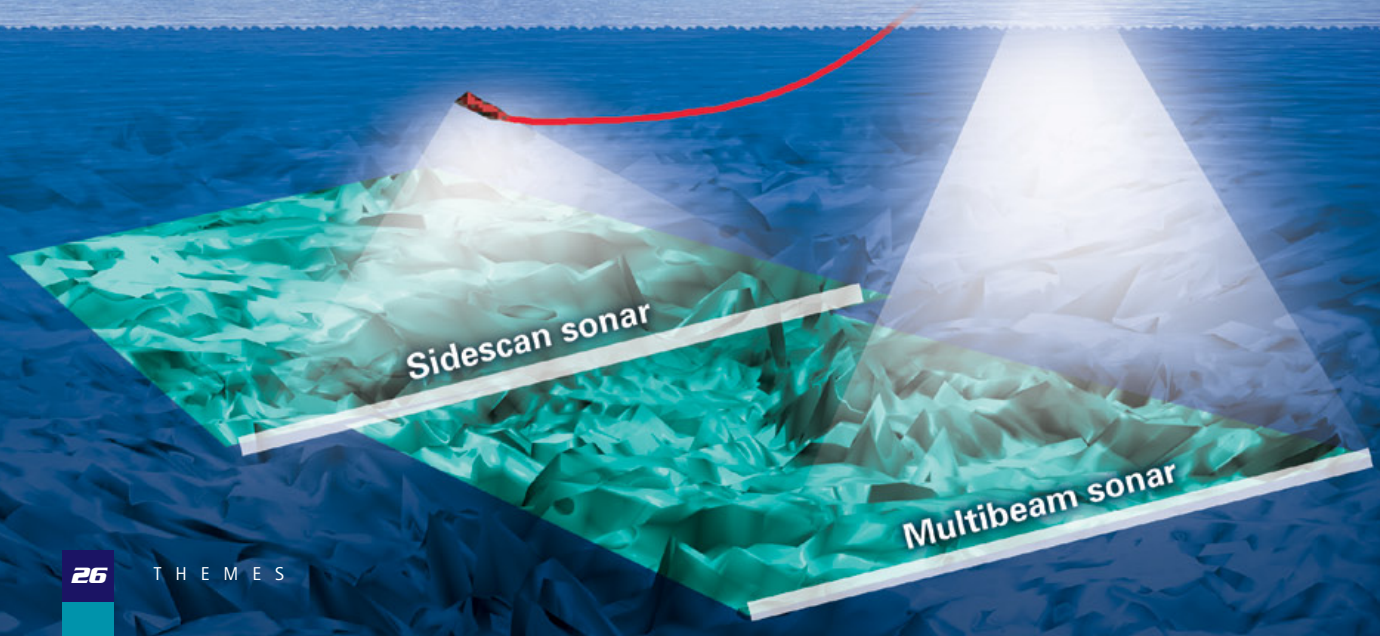
Mapping and survey projects sponsored by NOAA's Office of Ocean Exploration (OE) in 2003 covered more than 50,000 square nautical miles of previously uncharted ocean floor. Yet, Earth's oceans remain largely a mystery, with nearly 95 percent of the ocean floor unexplored—unseen by humans eyes.

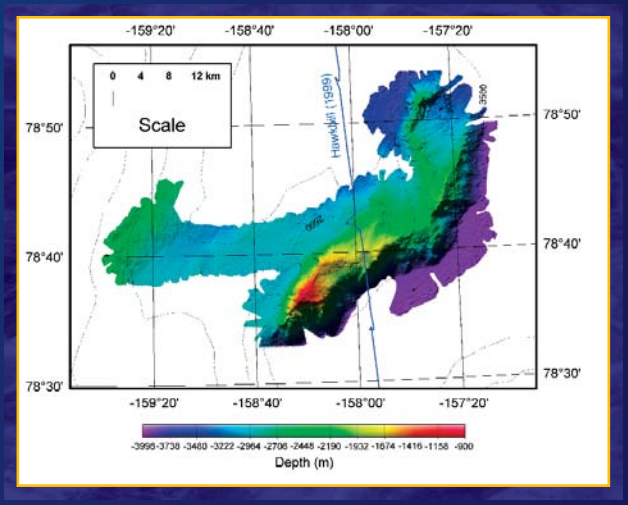


Mapping the physical, biological, geological, chemical, and archaeological aspects of the ocean provides knowledge necessary for characterizing the entire marine environment. To maximize vessel resources and opportunities and to avoid redundant research, OE identifies, encourages and supports transit mapping and other mapping of opportunity, especially when mapping is not a planned objective of a voyage.

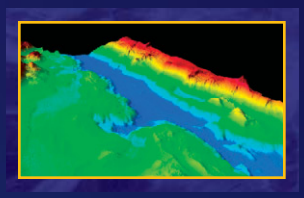
Partnerships in mapping, both internal and external to NOAA, have been key to the success of OE's mapping objectives. NOAA's Office of Coast Survey (OCS), the nation's leader in maintaining nautical charts for safe navigation, professionally maps our ocean floor daily. OE seeks to combine the knowledge and resources of OCS, with the needs and capabilities of other marine scientists who could benefit from their tools and techniques. In 2003, OE sponsored five OCS hydrographic survey technicians and physical scientists to assist in acquiring and processing mapping data on three separate expeditions. Their professional skills and expertise significantly improved the maps created on OE cruises when they helped scientists generate faster, more accurate results.

In addition to aligning mapping efforts internally, OE is continuing to look externally to chart under-explored areas of the globe. A major component beyond NOAA's inventory of expertise is a marine geology capability to map and define new geological features and resources. NOAA has looked for assistance from other federal agencies, such as from NOAA's long time partnership with the U.S. Geological Survey (USGS). An example of from partnership in 2003 was the further mapping of the Puerto Rico Trench as led by Dr. Uri Ten Brink from USGS, on two separate cruises aboard the NOAA ship *Ronald H. Brown*.





OE also contracted for existing and emerging capabilities in remotely operated vehicles, human occupied vehicles, and autonomous underwater vehicles for mapping purposes aboard NOAA's fleet and the many academic and private platforms OE uses annually. These actions further defined the role for industry in ocean exploration and science, and sustain NOAA's involvement with the latest commercial ocean technology. Several OE projects used mapping technology, even when mapping was not the main objective. Projects included the investigation of the Kick'em Jenny volcano off Grenada, surveying New England seamounts in the North Atlantic, and bio-prospecting surveys in the Gulf of Mexico.

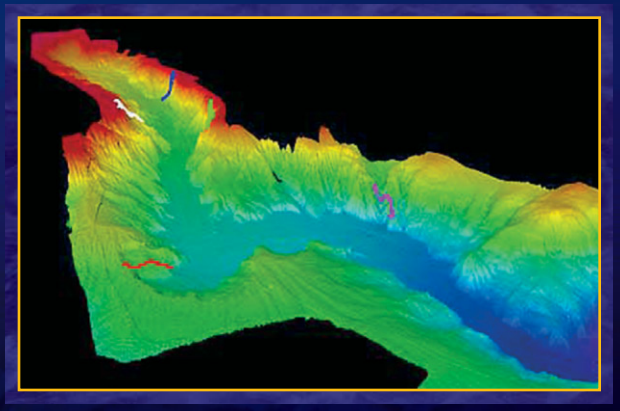


Collaborative ocean mapping requires coordination with OE projects using sonar technology for bathymetry and habitat characterization, mid-water multibeam for pelagic resource mapping, and low frequency towed source survey for geological mapping. This level of effort often involves mapping the U.S. continental shelf and important ocean features, focusing on areas under U.S. jurisdiction but including other areas that are unknown or poorly known.

In September, Arctic and hydrographic researchers led by Dr. Larry Mayer from the Center for Coastal and Ocean Mapping at the University of New Hampshire embarked on a 10-day Arctic Ocean mapping expedition exploring the Chukchi and Northwind Ridge. This mission focused on creating detailed bathymetric maps that could be used to justify expanding the U.S. Exclusive Economic Zone (EEZ) north of Alaska.

The team sailed aboard the US Coast Guard Icebreaker *Healy*, equipped with a hull-mounted Seabeam multibeam sonar capable of sensing the ocean floor at great depths. The bathymetric and backscatter imagery data created by the multibeam sonar provided important information into the tectonic processes affecting the ocean basin. In particular, Dr. Mayer's team addressed questions regarding the extent of grounded ice on the Chukchi Plateau. Confirmation of the extent of ice-grounding in this region is of great importance to understanding the history of Pleistocene glaciation in the Northern Hemisphere.

Systematically mapping and defining our marine environment is an elemental first step to better understanding our marine resources. Comprehensive mapping activities characterize areas of research including hydrography, living marine resources, essential fish habitats, coral communities, hydrothermal vents, gas seeps, and marine archaeology sites. Maps generated from OE expeditions facilitate an important national effort to inventory our national resources in the sea, and provide complete information for stewardship and management of the ecosystems that we seek to define and protect. For many disciplines, mapping is the only way to establish a baseline for determining future research needs, and OE will continue to work with researchers to map uncharted areas in 2004. ■



Ocean Interactions and Dynamics

The President's panel on ocean exploration that initially articulated the idea of our national Ocean Exploration Program put forth several challenges to the new program that were to become its objectives. These challenges were meant to be bold, ambitious and approached in new ways. One of these objectives is to explore ocean dynamics and interactions at new scales, thus helping to explaining new or poorly understood phenomena. The approach to exploring ocean dynamics and interactions, as defined by the President's Panel Report, is to assess many of the individual properties and characteristics that are a part of the complex interactions making up the oceanic environment.

These individual properties and characteristics cover a huge range of almost anything oceanic, and include assessments of water mass properties, such as its temperature, salinity, circulation, organic and inorganic chemicals, and geologic controls. It also includes an assessment of water mass ecosystem characteristics such as organic cycling, habitats and habitat associations, and community associations. Finally, the Ocean Exploration Program should include assessments of the spatial extent of water masses and variations in water masses over time.

The NOAA Office of Ocean Exploration (OE) has approached this challenge of exploring ocean dynamics and interactions through the organization of its multi-disciplinary oceanographic cruises that always explore new aspects of an ocean area. Through a panel review of experts, projects that are proposed for receiving a grant are reviewed for their scientific merit, their relevance to NOAA's goals, and their accordance with the objectives set forth for the Ocean Exploration Program. Many of these properties and characteristics are therefore ensured to be a part of most expeditions.

Most OE expeditions examined some facet of ocean dynamics and interactions, and often multiple ones. The following are examples from some of the 2003 OE cruises that illustrate OE's accomplishment in exploring ocean dynamics and interactions.

- During the month of February, an expedition to the Mariana Arc in the western Pacific, called the Submarine Ring of Fire, took place. This expedition examined submarine volcanoes, looking primarily for hydrothermal activity. The latest sea-floor mapping tools and sensors were used to image the volcanoes and to detect plumes of heat, gas and metals rising from the hydrothermal systems along the arc. These plumes represent an unexplored hydrothermal source that may inject globally significant fluxes of heat and chemicals into the oceans, having an untold influence on our planet.
- The interactions and dynamics of seamount biota were explored during the Mountains in the Sea expedition that took place on the New England Seamount chain. A key goal was to investigate the relationship of fishes and associated species such as squids, with features of seamount landscapes. The distribution of deep-sea corals in this unique environment was also explored with respect to the seamount landscape, revealing some level of zonation based on these environmental factors.

The Windows to the Deep expedition to the Blake Ridge focused on methane seeps and their associated chemosynthetic communities. These communities consist of extensive fields of clams and mussels (some up to 30 cm long) as well as worms in tubes, shrimp, and bacteria. Samples of these communities were collected to better understand their relationship to the methane seep, as well as the seep itself. Knowledge of methane seeps is important because of their potential as a future energy source as well as their potential contribution to climate change.

- Off the coast of South Carolina lies the Charleston Bump, a unique geological feature that greatly influences the flow of water in that area, creating a zone of gyrating eddies and swift, narrow currents. The Investigation of the Charleston Bump explored the very unique and specialized communities that have adapted to life in these turbulent waters, focusing on the interaction of habitats with the circulation and currents. Investigators collected samples of rocks and sediments, as well as specimens of fishes and invertebrates such as sponges and deep-water corals that were found in different areas of the diverse landscape.

Two discrete deep-sea communities on the continental slope were explored during the Life on the Edge expedition. The objective was to document the locations and aerial extent of portions of the deep-reef habitats, especially on a small scale, as well as document the biodiversity of deep-reef fauna by quantifying habitats, species associations, and behaviors. These objectives were addressed in part by sampling the entire water column in order to understand all possible habitat influences.

- The Kick'em Jenny Volcano was explored in March to learn about the growth and development of submarine volcanoes into eventual islands. An important discovery made regarding its development is that Kick'em Jenny is continuously releasing gas bubbles, confirming scientists' previous beliefs that the volcano is actively degassing. This interaction with the ocean is important because this process can significantly lower the density of the water, thereby posing a serious danger to shipping or boating in the area. Investigators also explored the volcano's relationship to the natural environment and unique biota that surround the hydrothermal venting in the area.

Ocean Exploration Technology:
NEW SENSORS AND TOOLS

The NOAA Office of Ocean Exploration (OE) technology program is built on strong relationships across NOAA, other federal agencies and the wider ocean engineering community. These relationships allow cooperative technology investments which are frequently the only way to support the high costs of ocean sensors and platforms. Regular communication with partners such as the National Science Foundation (NSF), National Aeronautics and Space Administration (NASA), and the U.S. Navy ensures that NOAA is working in cooperation with other major sponsors of technology research.

Technical excellence is a core value in the OE program. Strong ties to technology development labs keep the program at the cutting edge of ocean engineering. During 2003, OE worked with engineers at the Woods Hole Oceanographic Institution (WHOI), Institute for Exploration (IFE), the Naval Undersea Warfare Center (NUWC) and other leading institutions.

In ongoing science programs, OE also works to apply the latest industrial technology to exploration. This effort included the deployment of a commercially-provided remotely operated vehicle (ROV), Sonsub Incorporated's *Innovator*, on the NOAA ship *Ronald H. Brown* during the 2003 field season.

The 2003 OE technology program was conducted through grants solicited during the annual announcement of opportunity, cooperative ventures with other federal agencies and a significant effort to communicate and collaborate across NOAA.

OE is a leader in the promotion of autonomous underwater vehicles (AUVs) within NOAA. AUVs, which are unmanned robotic submarines operating without tethers or remote controls, provide a new approach to missions ranging from hydrographic surveying and habitat assessment to mid-water oceanography and marine archaeology. AUVs are the next generation of deep-ocean vehicles, beyond remotely operated vehicles (ROVs) and human occupied vehicles (HOVs).

OE supports teams from across NOAA interested in this new technology. During 2003, The National Marine Fisheries Service (NMFS), The National Undersea Research Program (NURP) and The Office of Coast Survey (OCS) all developed AUV programs with OE's support. Prototype procurement is underway and all three efforts will deploy AUVs in 2004.

2003 TECHNOLOGY PROGRAM

- Supported search for submerged Space Shuttle Columbia wreckage
- Synthesized technology and teams from multiple agencies for demonstration project at Kennedy Space Center
- Funded and advised NOAA AUV procurements
- Demonstrated live ultra-high resolution "telepresence" from an expedition in the Black Sea
- Upgraded the capabilities of WHOI's Autonomous Benthic Explorer (ABE)

To further the development of AUVs, and their deployment across NOAA and the ocean exploration community, during 2003 OE established a partnership with the Naval Undersea Warfare Center, which serves as a center of excellence in AUV technology for the U.S. Navy.

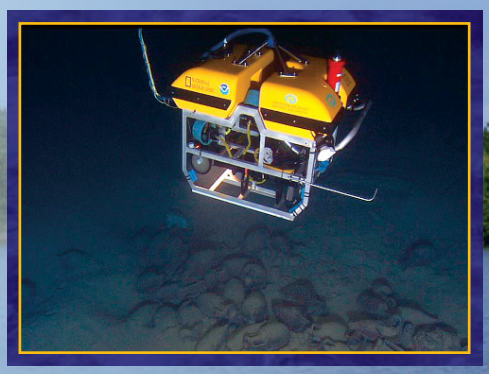
During 2003, OE supported a unique gathering of agencies, technologies and investigators to demonstrate the potential of leveraging technology programs. In August, 30 representatives from eight agencies convened in a NASA Kennedy Space Center (KSC) conference room to kickoff the Joint Environmental Science Investigations (JESI). The project objective was to apply a diverse set of tools combined in a new systems approach, to explore the aquatic environment of the Merritt Island National Wildlife Refuge, which surrounds KSC. The non-NOAA participants included:

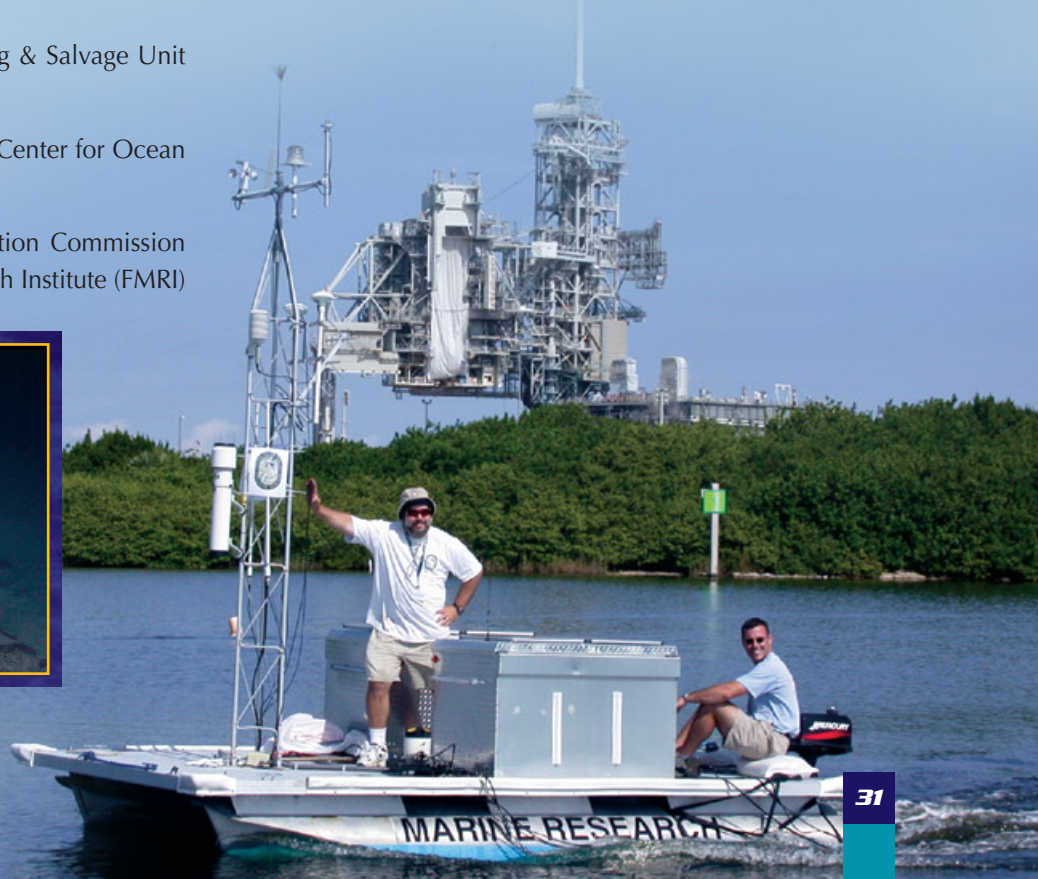
- National Aeronautics and Space Administration (NASA) Kennedy Space Center (KSC) and Jet Propulsion Laboratory (JPL)
- Naval Undersea Warfare Center (NUWC) Division Newport
- United States Coast Guard (USCG) Research & Development Center
- Dynamac Corporation
- United States Navy Mobile Diving & Salvage Unit Two (MDSU-2)
- University of South Florida (USF) Center for Ocean Technology (COT)
- Florida Fish & Wildlife Conservation Commission (FFWCC) / Florida Marine Research Institute (FMRI)

Team members operated and deployed many new technologies. AUVs were used for physical oceanographic sampling and bottom mapping. Passive acoustics, including advanced systems developed by the U.S. Navy and the passive acoustic monitoring system (PAMS) developed by NASA, were used to listen in as marine life used the marine reserve for spawning and as a year-round habitat. Several in *situ* sensors, including systems from NASA, Dynamac, USF and FMRI, were deployed in coordination with the AUVs and acoustics to collect additional data.

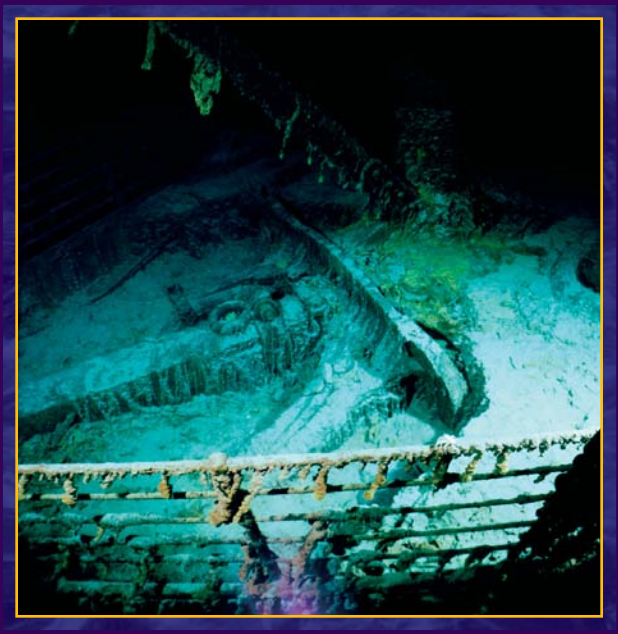
This joint effort brought together multiple and diverse agencies for cooperative research in a secure and environmentally sensitive area. The processes developed will be similar for future cooperative programs between these agencies and the program paved the way for and will increase the pace of cooperation and collaboration. JESI also demonstrated synergistic use of varied sensors and platforms for comprehensive monitoring of marine areas. This approach can widely benefit many missions including maritime security, environmental monitoring and ocean exploration.

Based on the success of this interagency approach, 2004 technology collaborations are planned, especially with NASA and the U.S. Navy. ■





Exploring our Maritime Heritage



NOAA's Office of Ocean Exploration (OE) explores submerged cultural resources and supports multidisciplinary teams and collaborative programs to discover new cultural resources, sharing knowledge about our maritime heritage.

Working primarily in the initial phases of exploration and discovery, OE systematically surveys and locates sites of archaeological or historical significance and engages the public with new information. NOAA sponsored projects and expeditions in 2003 that investigated cultural sites throughout the world.

For example, NOAA helped sponsor the return of Dr. Robert Ballard's Institute for Exploration (IFE) to the Black Sea to explore ancient shipwrecks and possible man-made settlements. The cold, anoxic waters of the Black Sea create ideal conditions for preserving organic material such as ancient wooden shipwrecks, which were discovered in previous missions. IFE brought new technology including a remotely operated vehicle (ROV) specially designed to conduct underwater archaeological surveys, and an innovative system to transmit images via satellite to the U.S. where they were distributed live on Internet and Internet II worldwide. The expedition was the first time National Science Foundation, another expedition sponsor, allocated dedicated ship time to a maritime archaeology project.

NOAA sponsored a number of academic-based expeditions in 2003. Researchers from the University of Rhode Island and Mystic Seaport searched for the remains of the *Gaspee* and other American Revolutionary War wrecks in Narragansett Bay, Rhode Island using side-scan sonar and magnetometer equipment, and for the second year in a row, graduate students from East Carolina University investigated wreck sites in the Outer Banks off Ocracoke Inlet, North Carolina.

An investigation of cultural resources does not end with new discoveries. OE, in conjunction with the NOAA Maritime Heritage Program created by the National Marine Sanctuary Program (NMSP), led an initiative with each coastal state to establish and strengthen the management of our nation's coastal historical resources. In cases where coastal states lack programs to inventory, assess, and protect historic shipwrecks, NOAA OE worked with them toward an exchange of information and data, hydrographic survey results from Office of Coast Survey (OCS), and regulatory and policy experience with the NMSP permitting system and the NOAA General Counsel.

To help address resources NOAA is already responsible for managing, OE continued to collaborate internally with OCS on new wrecks found in nautical charting surveys, and with NMSP to explore cultural resources in

their jurisdiction. Projects included further investigations of SS *Portland* and other wrecks in Stellwagen Bank NMS, as well as further ROV research in Thunder Bay National Marine Sanctuary and Underwater Preserve.

OE undertakes projects in the following areas as they relate to cultural heritage and the maritime landscape:

- All shipwrecks within state and federal waters
- U.S. flag ships wrecked throughout the world
- Submerged, prehistoric landscapes
- Historical structures directly pertaining to maritime heritage
- Shipwrecks holding a unique place in history, wherever they may be found.

NOAA has a vested interest in the appropriate treatment of *Titanic* as per the RMS *Titanic* Maritime Memorial Act passed by Congress in 1986. In June, OE conducted two days of intensive diving and research as part of an 11-day expedition to the site of the *Titanic* shipwreck aboard the Russian science vessel R/V *Akademik Mstislav Keldysh*, a vessel with two deep-diving submersibles. OE assessed the wreck site and conducted observations supporting on-going scientific research. Members of the international maritime archaeology and science communities participated and offered expertise.

NOAA and the National Park Service (NPS) worked together to assess, protect and preserve our nation's submerged historical resources. In November, OE assisted the NPS Submerged Resources Center with research at the USS *Arizona* Memorial in Pearl Harbor, Hawaii. NPS routinely monitors the shallow wreck site to see how the warm salt water degrades the ship, and how the wreck may be affecting the surrounding marine environment. OE assisted ROV and dive operations, and provided data management support.

OE and NMSP assisted another federal partner, the Office of Naval Research (ONR) in assessing the possible location of the Navy's first submarine USS *Alligator*, a Civil War era vessel lost off Cape Hatteras during a storm. The team uncovered rare historical documents in France, created oceanographic and engineering models, and laid out a possible search area. This effort included a small, exploratory research cruise sponsored by ONR that took place last summer aboard the NOAA ship *Thomas Jefferson*.

Many OE-sponsored maritime heritage projects would not have been successful, and in some cases not even possible, without the assistance of industry-developed ROVs and autonomous underwater vehicles and their associated skilled people. One government and industry partnership was an expedition on the NOAA ship *Ronald H. Brown* documenting the archaeological remains and biological habitat of the German submarine U-166 wreck lying upright at a depth of 5000 feet in the Gulf of Mexico. This was a collaborative effort between NOAA, C & C Technologies, Inc., Sonsub International, Sonardyne, and the PAST Foundation.

With the *President's Panel Report on Ocean Exploration* and the report of the National Academy's *Exploration of the Seas* both highlighting the importance of the nation's maritime history as told through the discovery and study of shipwrecks, NOAA continues to focus on the science and history of shipwrecks and works to integrate the efforts of government, academia and industry to benefit coastal states and the nation.

Ocean Exploration Education and Outreach

A cornerstone of NOAA's Ocean Exploration (OE) program is to reach out to the public to communicate how and why unlocking the secrets of the ocean will benefit current and future generations. With 10 percent of its annual budget dedicated to education and outreach activities, the program strives to engage the broadest possible audiences and to raise America's environmental literacy, an effort channeled largely through high-quality, effective collaborations between ocean explorers and America's teachers. Collaborative efforts included the development of educational opportunities, materials, and resources that brought entire classrooms "on board" for exploration and discovery during NOAA's multidisciplinary voyages of discovery.

The education section of the Ocean Explorer Web site (http://oceanexplorer.noaa.gov) provides direct access to more than 150 lesson plans developed by scientists and educators, more than 60 of which were produced in 2003. Lesson plans correspond to specific expeditions and are correlated to National Science Education Standards. For many expeditions, scientists and educators file daily logs and images from sea and this supplements lesson plans as an invaluable educational resource. Teachers can search lesson plans on the Ocean Explorer Web site by grade level, subject area, key word, region, and expedition name. A listing of professional development opportunities and information on how to request the OE CD-ROM is also included.

Six Professional Development Institutes (PDIs) were conducted including those for teachers in South Carolina and Georgia for the Charleston Bump expedition, in Mississippi for the Gulf of Mexico Deep Habitats and Gulf of Mexico Carney/Fisher expeditions, in Connecticut and Massachusetts for the New England

Seamounts expedition, and in Florida for the Islands in the Stream expedition. One included a live audio chat between teachers in Charleston, scientists and educators at sea, and the crew in Woods Hole Oceanographic Institution's manned submersible *Alvin* while it was on the ocean bottom.

A curriculum titled *Learning Ocean Science through Ocean Exploration* was created for national-level professional development in ocean science content for teachers of grades 6-12. Lesson plans take an inquiry-based approach through themes that cut across ocean expeditions. Ocean science themes progress from physical science through earth science to biological and environmental science, as ocean sciences include all of these areas. Supplemental activity booklets were produced for four expeditions.

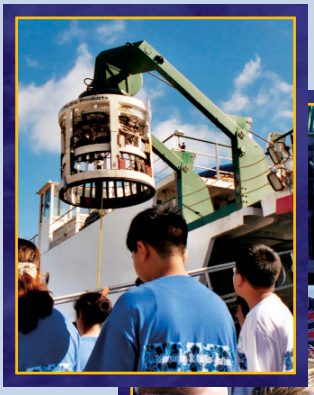
What is unique in this approach is the combination of the Ocean Explorer Web Site with each lesson. Teachers and students have a direct connection to the scientists whose work they are modeling in the classroom and a direct connection to exciting new discoveries through NOAA ocean exploration.

Two Aquarium Partnerships were developed to provide professional development to teachers in use of *Learning Ocean Science through Ocean Exploration* curriculum. The Monterey Bay Aquarium Research Institute and the Audubon Aquarium of the Americas have agreed to offer professional development in the use of the curriculum to help build regional cadres of ocean exploration teacher leaders. Additionally, plans for a third partnership with the South Carolina Aquarium were initiated.

In partnership with the National Marine Educators Association (NMEA), an issue of *Current, The Journal of Marine Education,* focused on the Arctic 2002 Expedition. In collaboration with NASA, the Ocean Exploration program developed a video-based, interactive career component for the Ocean Explorer Web site, entitled OceanA.G.E (Another Generation of Explorers). Through OceanA.G.E., students are invited to interact with talented women and men who explore our ocean planet on NOAA Ocean Exploration expeditions.

OE and the National Geographic Society co-hosted a nine-part virtual teacher workshop series to communicate how the excitement of ocean exploration can enhance learning in the classroom. The series ran from April through December 2003. Experts presented keynote lectures and facilitated open discussions.

To enhance ocean literacy, NOAA Ocean Exploration continued to foster numerous national and regional partnerships with the Marine Advanced Technology



Education National ROV Student Competition, collaborations with Stephen Low Productions and Rutgers University for the development of educational components for the *Volcanoes of the Deep Sea* IMAX Film, the National Centers for Ocean Science Education Excellence (COSEE) Council, and the Southeastern Center for Ocean Science Education Excellence (SECOSEE). NOAA worked with the Smithsonian Institution's National Museum of Natural History (NMNH) where an Ocean Hall is expected to be a premiere exhibit on the oceans when it opens in 2008.

OE coordinated four "Port Call" days during the 2003 expedition season. Held in Charleston, S.C., St. Petersburg, Fla., Gulfport, Miss., and Honolulu, Hawaii, port calls were associated with specific voyages of discovery and included media availabilities, tours for students and Ocean Education Expos. Expedition scientists opened their shipboard labs to reporters and groups of students to explain the mission and their findings and to display posters, sea-floor maps, videos and specimens recovered from the deep ocean. Interactions between scientists and students were positive and spirited.

Ocean Education Expos allowed area organizations to exhibit ocean-related educational themes and to distribute educational materials. Students were challenged to visit each exhibit for answers to questions posed to them in an "Ocean Science Scavenger Hunt" Port Call days also resulted in significant print and electronic media coverage.

Additional media coverage was generated nationally and regionally with the issuance of six news releases, media embarkations on expeditions, and interviews provided to the New York Times, Associated Press and numerous other media. "Our Ocean World" is a daily 90-second radio program carried by more than 150 radio stations and OE sponsors this program as part of its mission to raise ocean literacy. In 2003, the program reached an estimated 180 million listeners in the U.S. and another 35 million overseas. An opinion piece by the director of NOAA's Office of Ocean Exploration was carried nationally by Knight-Ridder as a year-end wrap-up story on ocean exploration in 2003.

In 2003, the NOAA Ocean Exploration program reached out to stakeholders in both traditional and new ways to help improve the ocean literacy of learners of all ages. In achieving ocean literacy, Americans can make informed decisions and take positive actions on vital ocean issues that affect the Earth and its inhabitants. ■

PHOTO CREDITS

Inside front cover – Top left photo: A pencil urchin collected at 1,750 ft depth has tubeworms attached to its spines. The view is from the under or "oral" side. Top right photo: Live nautiliniellid worm, removed from mantle cavity of the clam. Photo courtesy J. Dreyer. Middle right photo: While pursuing a larger fish, scientists happened to capture this unsuspecting goby, just 1.5 cm long. There are more than 2,000 species of goby found around the world. This family of fish includes the smallest of all vertebrate species. Many are amazingly cryptic. Depending on the species, these bottom-dwelling fish can be found living in crevices, burrows, or shell material on reefs or more exposed substrates. Photo courtesy Dave Wyanski, South Carolina Department of Natural Resources. Bottom photo: This small squat lobster, Galathea sp., shown here from the dorsal view, was collected incidentally as it perched on top of a sponge targeted for collection. Photo courtesy S. Bernhardt, FGBNMS.

Page 2 – Top left photo: Iceworms, Hesiocaeca methanicola, live within methane hydrates in the Northern Gulf of Mexico. NOAA photo. Top right photo: A close-up view of a basketstar. Bottom left photo: The planehead filefish is the most abundant species in our Sargassum collections. Its color and shape blend seamlessly into the seaweed. NOAA photo. Bottom right photo: This iridescent nudibranch looks like a creature from another planet, but was actually found attached to Sargassum. The clarity of the image reveals details of this one-inch organism that are almost impossible to see with the naked eye. Photo courtesy Art Howard, NAPRO.

Page 6 – Top left photo: Sonsub technicians recover their ROV Innovator after surveying the U-166. NOAA photo. Top right photo: Arctic researcher and hydrographer Dr. Martin Jakobsson aboard the *Healy*. NOAA photo. Bottom photo: The ROV *Hercules* recovered after investigating wrecks in the Black Sea. NOAA photo.

Page 7 – Microbiologist peers out the *MIR*'s porthole as the submersible descends to *Titanic*. NOAA photo.

Page 10 – Left photo: A deep sea *paragorgia* sp. Coral collected during the Mountains in the Sea cruise. Photo courtesy M. Crosby. Right photo: An open coral polyp as seen by the *Alvin*, showing some tentacles and pinnules during the Mountains in the Sea cruise. Photo courtesy WHOI.

Page 11 – Recovery of Woods Hole Oceanographic Institution's (WHOI) DSV *Alvin* during the Mountains in the Sea cruise with the WHOI R/V *Atlantis* in the background. Photo courtesy Catalina Martinez.

Page 12 – Left photo: Three live nautiliniellid worms in the mantle cavity of a vesicomyid clam collected at the Blake Ridge Diapir. Photo courtesy J. Dreyer, College of William and Mary. Right photo: A close-up view of a crustacean. NOAA photo.

Page 13 – WHOI DSV *Alvin* being launched during the Windows to the Deep expedition. Photo courtesy WHOI.

Page 14 – Left photo: A close-up view of a syllid worm collected on August 10, 2003. NOAA photo. Right photo: A close-up view of a crinoid. Photo courtesy Jerry McLelland, University of Southern Mississippi.

Page 15 – A 2,400 pound CTD used to collect information on the conductivity, temperature, and depth throughout the water column. NOAA photo.

Page 16 – Left photo: A close-up view of a sea urchin. Photo courtesy Art Howard, NAPRO. Right photo: A close-up view of a basketstar. NOAA photo.

Page 17 – A close-up view of a porcelain crab. Photo courtesy Liz Baird.

Page 18 – Left photo: Microbes isolated from a deep-water sponge. Right photo: Electrophoresis allows scientists to visualize DNA and RNA. NOAA/HBOI photos.

Page 19 – Tunicates that produce bioactive compounds. NOAA/HBOI photo.

Page 20 – A close-up view of a venus flytrap Unemone collected by the Sonsub *Innovator* ROV. NOAA photo.

Page 21 – Sonsub *Innovator* ROV deployment. NOAA photo.

Page 22 – Left photo: Mariana Island Arc volcanoes are overlain with the track of *T.G. Thompson* Cruise 153, 2003. Symbols for various features are shown in the legend. Names of volcanoes that are possible 2004 ROV dive targets in red. Right photo: Island and submerged volcanoes. NOAA photo.

Page 23 – Upper photo: Volcanic eruption. NOAA photo. Lower photo: Underwater volcano mapped. NOAA photo.

Page 24 – Left photo: Deep-ocean crab investigating a scavenger trap at a depth of 1000 m off Maro Reef. Photo courtesy Craig Smith and Eric Vetter. Right photo: An unidentified eight armed squid found drifting midwater. Photo courtesy Frank Parrish, National Marine Fisheries Service (NMFS).

Page 25 – Deep-sea precious corals. Photo courtesy Amy Baco-Taylor.

Page 26 – Top photo: Reconnaissance map for a site in the Gulf of Mexico produced with Seabeam bathymetry data. NOAA image. Bottom photo: Renditions of side-scan and multibeam sonar images. NOAA image.

Page 27 – Top photo: A seamount discovered on the 2003 Arctic Mapping Expedition. Image courtesy CCOM/UNH. Middle photo: 3D model of the Puerto Rico Trench. NOAA image. Bottom photo: Three-dimensional image Astoria Canyon looking southeast. NOAA image.

Page 28 – Left photo: Smaller fishes, such as filefishes and triggerfishes, reside in and among the brown Sargassum. NOAA photo. Right photo: CTD launch. NOAA photo.

Page 29 – Squat lobster and lophelia. NOAA photo.

Page 30 – Left photo: Manipulator arm of ROV *ROPOS* places heat sensor in hydrothermal vent. NOAA photo. Right photo: Autonomous underwater vehicle (AUV). NOAA photo.

Page 31 – Left photo: Remotely operated vehicle (ROV). NOAA photo. Right photo: Joint environmental science investigations at NASA Kennedy Space Center. NOAA photo.

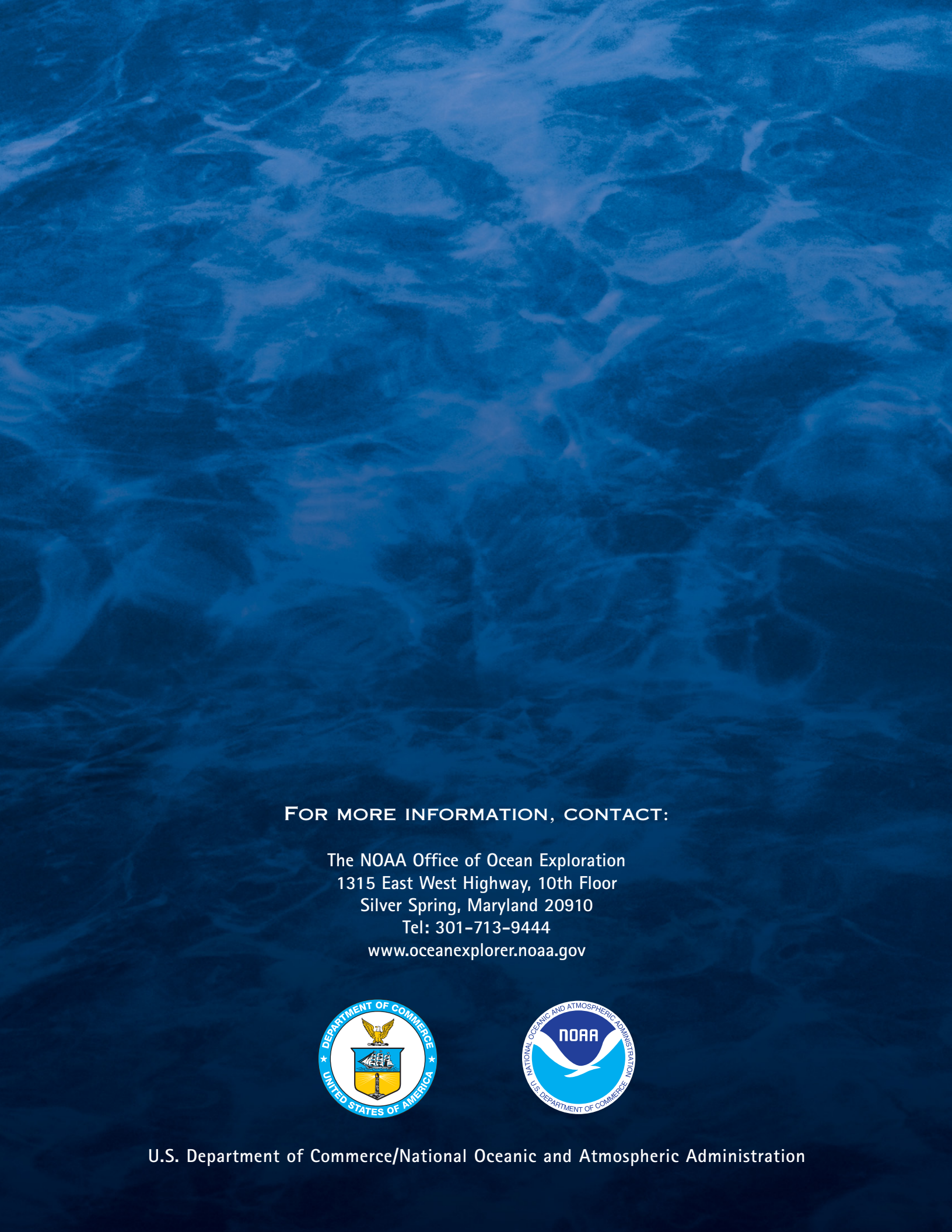
Page 32 – Left photo: Spare anchor on the bow of RMS *Titanic*. NOAA photo. Right photo: A piece of ancient amphora recovered from the 2003 Black Sea Expedition. NOAA photo.

Page 33 – Russian crewmembers prepare the submersible, *MIR II*, for deployment. NOAA photo.

Page 34 – Top right photo: Students from Gulfport, MS. interested in the science of medicine from the sea. NOAA photo. Bottom right photo: Students in Hawaii visit scientists in a lab aboard the research vessel. NOAA photo.

Page 35 – Top left photo: Hawaii Undersea Research Laboratory's remotely operated vehicle (ROV) is swung out over the pier, demonstrating how the ship positions it for a dive. NOAA photo. Middle left photo: NOAA's Catalina Martinez briefs students in front of the NOAA ship *Ronald H. Brown*. NOAA photo. Bottom left photo: Students from Gulfport Miss. schools visited the NOAA ship *Ronald H. Brown* as the ship's science parties changed between missions. Sonsub's ROV Innovator however was on board for three successive deep sea missions in the Gulf of Mexico. NOAA Photo. Top right photo: Professor Craig Smith, University of Hawaii at Manoa, is interviewed following a cruise. NOAA photo. Bottom right photo: The Kai'imikai-o-Kanaloa operated by NOAA's Hawaii Undersea Research Laboratory at the University of Hawaii. NOAA photo.

Page 36 – Oceanexplorer web page samples courtesy NOAA.



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